SCIENTIFIC REPORTS

OF THE

Agricultural Research Institute, Pusa

(Including the Reports of the Imperial Dairy Expert, Physiological Chemist, Government Sugarcane Expert, and Secretary, Sugar Bureau)

1927-28

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Scientific Reports of the Agricultural Research Institute, Pusa

(Including the Reports of the Imperial Dairy Expert, Physiological Chemist, Government Sugarcane Expert, and Secretary, Sugar Bureau)

1927-28

REPORT OF THE DIRECTOR.

(D. Clouston, C.I.E., M.A., D.Sc.; and W. H. Harrison, D.Sc.)

I. Charge and Staff.

Charge. Dr. D. Clouston, C.I.E., held charge of the office of Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, throughout the year. He performed the duties of Liaison Officer between the Royal Commission on Agriculture and the Government of India and the Local Governments from 21st October, 1927, to 14th April, 1928, in addition to his own duties.

The post of Joint Director was held by Dr. W. H. Harrison throughout the year under report.

Staff. Mr. G. S. Henderson, Imperial Agriculturist, served as a Member of the Government of India Committee on Opium from 16th November, 1927, to 30th April, 1928, in addition to his own duties.

Mr. Aga Muhammad Mustafa, Agronomist, has been deputed to officiate as Agricultural Officer, North-West Frontier Province, for two years from 1st October, 1927.

Khan Sahib Abdur Rahman Khan was relieved of the current duties of the post of Imperial Economic Botanist on 18th November, 1927, on the return of Dr. F. J. F. Shaw from leave.

During the absence of Mr. T. Bainbrigge Fletcher on leave for four months from 4th May, 1928, Mr. P. V. Issac officiated as Imperial Entomologist, and Rai Bahadur C. S. Misra carried on the current duties of the post of Second Entomologist (Dipterist).

Mr. J. H. Walton having proceeded on six and half months' leave from 1st May, 1928, Mr. N. V. Joshi was placed in charge of the current

duties of the post of Imperial Agricultural Bacteriologist. Mr. Joshi was also in charge from 16th October to 2nd November, 1927, when Mr. Walton was on training with the Army in India Reserve of Officers.

The services of Mr. Wynne Sayer, Secretary, Sugar Bureau, were placed at the disposal of Messrs. Finlay, Fleming & Co., Rangoon, for one month from 22nd March, 1928, in connection with questions of sugarcane cultivation, manuring, etc. on their estate at Sahmaw in Upper Burma. Mr. Sayer was under training with the Army in India Reserve of Officers during February 1928. During these periods, Rao Sahib Kasanji D. Naik was in charge of the current duties of the post of Secretary, Sugar Bureau.

On return from deputation to the Forest Research Instituete, Dehra Dun, Dr. J. Sen took charge of the duties of Plant Biological Chemist on 11th April, 1928.

II. Research.

The research work done by the Institute aims at establishing principles which can be put into general practice by provincial agencies. The more important work of the year under report is summarized below :—

Botanical Section. In a year remarkable for the heavy incidence of rust brought on by the prolonged damp cloudy weather in January and February, the rust-resisting capacity of various Pusa wheat selections was severely tested. Pusa 52 and Pusa 4 proved to be the most resistant, and Pusa 12 and Pusa 80-5 the most susceptible. Pusa 52 being the least affected by rust yielded 3,286 lb. of grain on an area of 1·78 acres. Pusa 111, a smooth-glumed variant of Pusa 4 recently isolated, proved even more resistant than the latter. Another promising new type is Pusa 114, a bearded variant of Federation. Besides possessing these desirable characters, the new wheats promise to be superior to Pusa 4 in " hardness ". Two selections of oats, which will be termed in future B. S. Types 1 and 2, having proved superior in yield to Pusa Farm oats, are to be tried on a field scale. Samples of Adcock tobacco leaf produced at Pusa this season showed the nearest approach attained so far to the corresponding American type, and marked considerable improvement on the bright Indian leaf raised in the past. The results obtained with regard to the methods of cultivating and flue-curing (which are being published separately as a Pusa Bulletin) are very promising, and the ratio of cost to price shows a satisfactory profit to the grower. Pusa linseed Type 124 has maintained its superiority over Types 12 and 121 as regards oil content. Efforts are also being made to evolve superior varieties of barley, maize, gram, safflower, sesamum, peas, *mung* (*Phaseolus mungo*), *urid* (*P.*

radiatus), *masur* (*Lens esculenta*), pigeon-pea and chillies, either through selective breeding or hybridization.

Chemical Section. Of the various manures experimented with, the canes manured with potash and superphosphate yielded juices of the highest quality, though the yield was markedly low. From the point of view of yield, the best combination was superphosphate and sulphate of ammonia. The acetic ether test for the detection of adulterants in butter fat was found effective for all cow butters and for buffalo butter made from the milk of animals not fed on cotton seed. Butters from buffaloes fed on cotton seed are rejected by this test and in these cases it is necessary to apply Halphen's test and if a positive result is obtained, a slight modification of the proportions of acetic ether and alcohol permits of a reliable deduction being obtained. Experiments to test the efficacy of different methods of curing tobacco, their effect on the composition of the leaf and the changes which occur during the process of curing were continued. The use of antimony electrodes for the estimation of acidity and alkalinity in soils showed that definite reproducible pH values could be obtained and that the electrodes are very suitable for use in the field either for soil surveys or for the study of changes *in situ*. The Physical Chemist continued to investigate the base exchange capacity of the soil and the effect on its germinating capacity of storing wheat at different humidities.

Bacteriological Section. An investigation into the fluctuations in the total nitrogen content of different plots under permanent manurial experiments at Pusa has shown that the soil of plot No. 16A (green manure and superphosphate) contains the largest amount of nitrogen. Further experiments on nitrification were carried out with a view to finding out in what form and under what conditions loss of nitrogen takes place when large amounts of nitrogen get concentrated in the soil. The superiority of bonemeal-sulphur-sand-charcoal compost over superphosphate and bonemeal was demonstrated when applied to soils cropped with potatoes, onions and wheat. A method of manufacturing vinegar from cane juice, *gur*, molasses, etc., by using a concentration of 7 per cent. acetic acid at 30° C. was devised. Experiments on the storage of raw, half ripe and ripe mangoes were conducted, with a view to finding out how far the ripening enzyme is affected by a low temperature.

Mycological Section. The record of pigeon-pea wilt in the manurial plots seems to suggest that the application of superphosphate stimulates the disease ; that green manure is unfavourable to it, and that when both are applied they have an effect intermediate between the two applied singly. The presence of mosaic disease in certain localities and varieties of cane in which it has not been previously noticed was report-

ed during the year. Observations made at Pusa indicate that Co. 205 is very susceptible to this disease; Co. 250, 287 and 213 are fairly susceptible; Co. 210, 273, 275, 281, 282, 286 and 288 are resistant; and Co. 214, 248, 270, 280 and 290 are highly resistant. In cane fields on seven estates in North Bihar, Co. 205, 210 and 213 were found to be less affected than Hemja which they are gradually replacing. Roguing carried out in the last two seasons has reduced the incidence of disease to below 0·5 per cent. in every case except in that of Co. 205. Field work carried out during the year showed that each of the two methods worked out in the laboratory of preventing smut in *kodon*, *viz.*, (1) by steeping the seed in copper sulphate and (2) by dusting it with copper carbonate, was effective in reducing the amount of smut from about 50 per cent. to less than 1 per cent. Wilts of pigeon-pea, cotton, sesamum, gram and linseed were among other diseases under investigation.

Entomological Section. Further experiments with *Pseudococcus* spp. *Aphis sacchari*, *Pyrilla* spp., *Assamia mœsta* and *Neomaskellia bergii* have shown that none of these sucking insects is concerned with the transmission of the mosaic and streak diseases of sugarcane. *Aphis maidis*, which causes mosaic in other countries, has been found to occur at Pusa on maize and sorghum. Work on cane-borers and their parasites was continued. The results obtained during the year indicated that the use of egg parasites would be the most effective method of checking *Scirpophaga nivella*. A study of the habits and life-history of the Braconid which is parasitic on the adult weevils of *Myllocerus 11-pustulatus* var. *maculosus* attacking cotton plants has shown that the adult parasites are active at Pusa till early April and do not disappear after the first week of February, as hitherto believed. Experiments carried out have proved that mercury used in stored wheat with a view to eliminating the danger of damage by weevils (*Sitophilus oryzae*) does not adversely affect either its germinating capacity or its food value. Work on the life-histories and distribution of Tabanidæ was continued.

Agricultural Section. The permanent manurial and rotational experiments carried on for a period of over 20 years have definitely proved the manurial value of superphosphate when applied in combination with a green-manure. An area of 413 acres heavily cropped for 16 years under a settled rotation shows a steady upward tendency in yield, but is subject to minor seasonal fluctuations, due chiefly to the amount of the rainfall. A separate area of land on the Pusa Estate known as the " New Area " is being devoted mainly to sugarcane experiments in which manures, seed-rates, times of planting, different varieties of cane and varying spacing distances for planting are being tested. Among the new Coimbatore canes under trial, Co. 270 gave the largest yield of stripped cane in the year under review. In the pure Sahiwal herd,

six cows gave over 4,800 lb. in a lactation period of 304 days ; among the half-bred progeny of rejected Sahiwal cows sired by Ayrshire or Holstein bulls, the yields of eight cows were over 7,600 lb. The average yield per cow per day for the year was 16·5 lb. as against 15·5 lb. in 1925-26. While the average percentage of cows in milk in the cross-bred herd was 68, in the pure herd it was only 51. The whole herd was as usual fed very largely on green fodders and silage throughout the year.

Imperial Dairy Expert. In accordance with the breeding policy adopted at Pusa, most of the cross-bred cows on the Bangalore and Wellington farms are now sired by Indian bulls of good milch pedigree. At Karnal, pure herds of Thar-Parkar and Hariana cattle and of Murra buffaloes and at Wellington and Bangalore herds of Scindi cows are being established. The Creamery at Anand is being used for the manufacture of butter on a factory scale. It is being utilized, too, for experimental work to some extent in connection with the transport of fresh milk to Bombay and the manufacture of *ghee*, condensed milk and casein. All these institutions, though largely intended for research and training purposes, are run on quasi-commercial lines. The Imperial Dairy Expert continued to give Provincial Departments of Agriculture, city municipal corporations, and private individuals advice and assistance in technical matters connected with dairying and cattle breeding. With a view to stimulating interest in these subjects, he delivered a certain number of lectures illustrated by cinema films.

Physiological Chemist. In feeding experiments on the nutrition of growing animals, spear grass silage combined with even a low allowance of concentrated food induced a higher increase in weight than spear grass hay or *ragi* (*Eleusine coracana*) straw combined with a high allowance of concentrates. Of the three breeds of cattle under trial, *viz.*, the Scindi, the Ongole and the Kangayam, the Scindi did best. Long-period feeding tests with coarse fodders have shown that the higher the protein allowance, the lower the digestion of the total carbohydrate and organic matter, though very striking differences were not noticeable. In experiments designed to determine the relation between the digestive capacity and the milk yield of different breeds of milch cows, cross-bred cows consumed 50 per cent. more food than Scindi cows. Scindi cows on going dry consumed less food : this is not noticeable in the case of cross-breds. When the concentrate is reduced, the latter keep up their food consumption by eating more roughage. Observations on diuresis were continued and the work has been extended with a view to studying certain important characteristics of cattle urine.

Government Sugarcane Expert. The area under medium and thin canes bred at Coimbatore is estimated to be in the neighbourhood of a lakh of acres. As these canes are not entirely suitable for the varying

soil and climatic conditions obtaining in Northern India attempts are being made to breed early tillering varieties which have hard rinds, a deep rooting system and are resistant to mosaic disease. A careful study of the flowering habits of thick canes has resulted in a remarkable increase in the number of thick seedlings raised during the 1927 arrowing season, as compared with that of 1926, the respective figures being 50,000 and 3,000.

Sugar Bureau. During the year under report, the services of the Secretary, Sugar Bureau, were lent to (1) the Government of Bombay to advise and report on the cane situation in the Deccan, (2) the Government of the Punjab to advise on the scheme for establishing a group of white sugar factories in that province, and (3) Messrs. Finlay, Fleming & Co. through the Government of Burma to guide them in placing the cane cultivation at their pioneer factory at Sahmaw on a sound basis. As the result of experimental plots laid down at three outstations in North Bihar, Co. 205 sugarcane has been well established both on low-lying and high lands, for this hardy cane does well on both. The Sugar Cable Service conducted by the Bureau on a self-supporting basis continues to receive the support of the trade.

III. Training.

Agricultural Research Institute, Pusa. The two-year post-graduate course was completed during the year by Messrs. Sailesh Chandra Roy, M.Sc., and Mahbub Alum, M.Sc., in Botany; by Abdus Sattar, B.Sc., in Mycology; by Sher Singh Mangat, M.Sc., in Chemistry; and by M. R. Madhoke, B.Sc., in Bacteriology. Mr. Sailesh Chandra Roy, while under training, was awarded a scholarship by the U. P. Government for study in England.

Of the 35 candidates for admission to the new session commencing on 1st November, 1927, four were considered by the Selection Committee to be qualified for post-graduate training, but one of them left soon after joining. An Entomological Assistant deputed by the United Provinces Government for training was admitted to a special course in Systematic Entomology. Ten post-graduate students of the Imperial Institute of Animal Husbandry and Dairying were given short courses at Pusa in estate management, cattle-breeding, plant diseases, etc. In addition, one student deputed by the Indian Central Cotton Committee was admitted to a one-year course in Entomology, and two sent by the Bengal Government were given short courses in lac-culture.

Imperial Institute of Animal Husbandry and Dairying, Bangalore. Four post-graduate students and one post-diploma student completed their 15-month course during the year. There were nine applicants

for admission during the current session; six were selected of whom five actually joined.

The third batch of students under training for the Indian Dairy Diploma completed their two-year course in December 1927. Of the 21 candidates appearing at the examination, 18 qualified for the Diploma, two with honours. Ten students of the Allahabad Agricultural Institute also presented themselves for the examination, of whom eight were successful. Twenty-seven students were enrolled for the new course which began at Bangalore in November 1927.

Short-courses in cattle-breeding and dairying were provided for six students from different provinces. Ten Dairy Diploma students from the Allahabad Agricultural Institute received technical instruction at the Bangalore and Karnal farms and the Anand Creamery.

IV. Publications.

Twenty-three memoirs, eleven bulletins and ten other publications were issued during the year, while 25 publications were in the press on 30th June, 1928. The publications issued dealt with subjects of general interest such as the improvement of varieties of rice, *jowar*, *bajra* and cotton, digestibility trials on Indian feeding stuffs, etc. A revised fourth edition of the Bulletin on Lac and a second edition of the Memoir on Indian cottons were sent to the press during the year. The *Agricultural Journal of India*, which is issued every two months, and the quarterly entitled the *Journal of the Central Bureau for Animal Husbandry and Dairying in India*, started in April, 1927, continued to maintain their popularity among the classes of readers for whom they are intended.

V. General Administration.

Buildings. The work in connection with the scheme for concentrating the Botanical Section in the area allotted to it has been completed. The construction of a set of six clerks' quarters undertaken during the year is in progress.

Library. In addition to 415 periodicals and 2,101 books, bulletins, circulars and reports received in exchange, 278 periodicals and 488 volumes of new books, bulletins, reports, etc., were purchased during the year. Out of 2,371 publications issued on loan, 195 were sent to officers of the Provincial Departments of Agriculture.

Hospital. Medical relief was afforded to 238 in-patients and 8,733 out-patients in 1927, as against 271 and 9,730, respectively, in 1926. Of the 1,529 operations performed, 22 were "selected" ones. Among cases of the more important tropical diseases, 584 were of malaria,

322 of Kala-azar, 131 of dysentery, 59 of hookworm diseases, 4 of cholera and 3 of leprosy.

The health of the residents on the Pusa Estate, on the whole, was satisfactory, and there were no serious outbreaks of epidemic diseases throughout the year.

VI. Accounts.

The total expenditure during the financial year ending 31st March 1928, as shown below, was Rs. 7,08,638, as against Rs. 7,56,984 in the previous year.

	Rs.
General expenditure of the Institute, including the Office of the Agricultural Adviser	2,45,990
Botanical Section.	38,515
Chemical Section.	61,749
Bacteriological Section.	51,277
Mycological Section.	44,046
Entomological Section.	72,280
Agricultural Section.	1,42,820
Sugar Bureau.	29,283
Sugar Cable Service	22,678.
Total	7,08,638

The following were the principal items of expenditure met from the grant of Rs. 5,000 placed at the disposal of the Agricultural Adviser for expenditure on special agricultural experiments.

	Rs.
Alterations in the tobacco curing barn in the Botanical Section	400
Erection of wire fencing in connection with experiments on mosaic by the Imperial Mycologist	1,170
Construction of furnaces for *gur*-making in the Agricultural Section	1,340
Construction of two trial silo pits at Karnal	1,000

The receipts during the year amounted to Rs. 98,520, as detailed below :—

	Rs.
Fees from students	2,225
Sale of farm produce	9,420
Sale of milk, cattle, etc.	34,448
Subscriptions to the Sugar Cable Service	31,588
Other receipts	20,839
Total	98,520

REPORT OF THE IMPERIAL ECONOMIC BOTANIST.

(F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S.)

I. Introduction.

Khan Sahib Abdur Rahman Khan was in charge of the Section until 21st November, 1927, when Dr. Shaw returned from leave. During the period 3rd to 31st October, 1927, Dr. Shaw was on deputation in England attending the Imperial Agricultural Research Conference. A sum of approximately Rs. 3,100 was realized from the sale of improved seeds and credited to Government during the past financial year.

The concentration of the Botanical Section in the area allotted to it was completed and the Botanical Laboratories in the Phipps Laboratory were vacated.

Training. Mr. Sailesh Chandra Roy, M.Sc., was awarded a post-graduate scholarship for study in England by the Government of the United Provinces of Agra and Oudh, and left the Section on 24th August 1927. Mr. Mahbub Alam, M.Sc., completed his course of study on 31st March, 1928 ; he is remaining in the Section as a voluntary research worker and is completing a research on the inheritance of characters in gram. Mr. Sawan Mal Sikka, a scholarship student sent for training by the Punjab Government, continued his course of instruction. Mr. R. B. Deshpande, an assistant to the Economic Botanist, Bombay, joined the Section as a post-graduate student in November 1927. Two classes of students from the Institute of Animal Husbandry and Dairying, Bangalore, attended special short courses during the year under review.

II. Investigations.

The year 1927-28 was on the whole not a favourable one ; the total rainfall was below normal, but there was an excess of damp cloudy weather in January and February which resulted in considerable damage to the *rabi* (spring) crop. The following Tables show the total rainfall

and the yields of crops in the Botanical Section in the year under review :—

Statement of rainfall at Pusa in 1927-28.

Month	Average for 20 years 1906-25	From 1st June 1927 to 31st May 1928	Difference
June 1927	8·30	6·32	—1·98
July	11·06	11·30	+0·24
August	14·61	8·03	—6·58
September	8·74	4·69	—4·05
October	1·32	0·17	—1·15
November	0·42	1·94	+1·52
December	0·07	..	—0·07
January 1928	0·22	1·31	+1·09
February	0·75	0·52	—0·23
March	0·40	..	—0·40
April	0·66	0·02	—0·64
May	1·59	0·96	—0·63

Statement showing the outturn of various crops grown in 1927-28.

Crop	Plot	Area in acre	Outturn of grain	
			Actual lb.	Per acre lb.
Wheat—				
P. 111 (smooth glumed).	Orchard 2A . .	0·18	371	2,061
P. 4 . . .	,, 2A . .	0·18	398	2,211
P. 4 . . .	Farm . . .	8·0	8,991	1,124
P. 80-5 . . .	Barah 6 . .	0·44	207	470
P. 6 . . .	N. T. G. 11 . .	0·39	465	1,192
P. 12 . . .	Orchard 2B . .	0·71	732	1,031

Statement showing the outturn of various crops grown in 1927-28—contd.

Crop	Plot	Area in acre	Outturn of grain	
			Actual lb.	Per acre lb.
Wheat—concld.				
P. 12	Orchard 2C	0·71	527	742
P. 52	N. T. G. 10	1·78	3,286	1,846
P. 90	Barah 5	0·47	393	839
Gram—				
T. 25	Barah 4 East	0·37	385	1,041
T. 25	„ 4 West	0·37	303	819
T. 17	River Bank West	0·74	709	958
Linseed—				
T. 124	S. T. G. 6	0·2	99	495
T. 12	„ 8	0·3	234	780
T. 121	Orchard 5B	0·6	688	1,147
Tobacco—				
Adcock leaf	Orchard 4B	2·0	2,140	1,070
Burley „	„ 5A	0·62	754	1,216
Oats—				
T. 12-1	Lawn plot 1	1·22	2,105	1,725
„	Musahar plots	2·93	4,317	1,473
„	Punjab plot	8·0	12,196	1,524
„	Brickfield	1·0	1,599	1,599
T. 19-1	Punjab plot	8·0	12,375	1,547
„	Brickfield	1·0	1,484	1,484
T. 14-2	Punjab plot	8·0	11,897	1,487
„	Brickfield	1·0	1,583	1,583
Rahar—				
A.	Orchard 6A	0·7	750	1,071
B.	„ 6A	0·7	890	1,271
C.	„ 6B	0·7	619	884
D.	„ 6B	0·7	836	1,194
E.	Pentagonal	0·28	129	461

Statement showing the outturn of various crops grown in 1927-28 concld.

Crop	Plot	Area in acre	Outturn of grain	
			Actual lb.	Per acre lb.
Rahar—concld.				
F.	Pentagonal	0·33	176	534
G.	„	0·64	486	759
H.	„	0·32	207	647
K.	„	0·35	125	357
M.	„	0·39	164	420
P.	„	0·43	196	456
R.	„	0·60	467	778

Wheat. The outstanding feature of the season as regards the wheat crop was the heavy incidence of rust brought on by the prolonged damp cloudy weather in January and February. The Pusa wheats varied considerably in their power of resistance to this attack, the most resistant wheats being Pusa 52 and Pusa 4, and the most susceptible being Pusa 12 and Pusa 80-5. The grain of these latter two wheats was thin and shrivelled and of such poor quality as not to be fit for distribution. This condition of the grain is apparent in a comparison of the bushel weights of Pusa wheats in the last three seasons :—

Wheat	Weights per bushel in pounds		
	1925-26	1926-27	1927-28
Pusa 4	64·9	63·0	63·25
Pusa 12	61·5	65·0	56·03
Pusa 52	65·5	63·0	62·17
Pusa 80-5	65·0	66·5	55·9
Pusa 90	64·25	64·0	60·16

The best yield of wheat in the Botanical Section in the past season was given by Pusa 52 which yielded 3,286 lb. on an area of 1·78 acres ; higher yields per acre of Pusa 4 were obtained, but the areas in these

cases were very small. In the season 1926-27, Pusa 4 gave 2,270 lb. per acre and Pusa 80-5 gave 2,500 lb. per acre on the Karnal Farm.

Two new types of wheat were tested on a small scale during the past season. These wheats were first observed in 1925 when they occurred as natural crosses in the wheat crops in the Section. Pusa 111 was fixed from a natural cross in Pusa 4 and resembles Pusa 4 in all respects except that it has smooth glumes, while those of Pusa 4 are hairy, and was more resistant to rust in the past season than Pusa 4. Pusa 114 was fixed from a natural cross in a crop of Federation and differs from this wheat in being fully bearded. Both the smooth-glumed character in the variant from Pusa 4 and the bearded character in the type from Federation are desirable variations and further tests will be carried out with these wheats. The results of an analysis of the flour of Pusa 4, Pusa 111 and Pusa 114, carried out by the Imperial Agricultural Chemist, suggests that the two new wheats will both prove to be " hard " wheats, superior in this respect to Pusa 4.

Analysis of the flour of Pusa 4, 111 and 114 wheats.

	Pusa 4	Pusa 111	Pusa 114
Moisture	9·48	9·22	9·06
Ether extract (Fats)	2·26	2·33	2·22
Crude proteids	14·39	14·53	17·02
Soluble carbohydrates	70·49	70·42	67·80
Woody fibre	1·68	1·70	1·93
Soluble mineral matter	1·59	1·72	1·90
Sand and silica	0·11	0·08	0·07
TOTAL	100·00	100·00	100·00
Total organic nitrogen per cent.	2·30	2·33	2·72
Albuminoid nitrogen per cent.	2·08	2·06	2·39
Albuminoids per cent.	13·02	12·89	14·95
Gluten per cent.	12·08	12·16	13·64
Starch per cent.	50·81	50·54	48·19
Food units	112·13	112·57	115·91
Albuminoids ratio	5·81	5·88	4·88

The third hybrid generations of crosses between Pusa 4 and Federation, and Pusa 52 and Federation, were grown and selections were made.

The severe attack of rust in the past season was of use in this work as it enabled selections for rust resistance to be made; estimations of the degree of infection in each culture were carried out by the Mycological Section, Pusa. The cultures from the cross from Pusa 52 proved much more resistant to rust than those from Pusa 4; this confirms the observation that Pusa 52 was the least affected by rust of any of the Pusa wheats during the past season. Some late maturing selections from both these crosses will be sent to the North-West Frontier Province and Karnal where they are likely to do better than at Pusa.

The study of biometrical data of the Pusa wheats was continued.

The demand for pure seed of the Pusa wheats was exceptionally heavy during the past year owing to the partial failure of the wheat crop in certain areas of the Central Provinces and Central India. Arrangements are being made on the Pusa Farm and at Karnal for the multiplication of Pusa seeds on a larger scale during the coming season. The following approximate quantities of the Pusa wheats were distributed to private cultivators and the Departments of Agriculture during the past year :—

	Mds.
Pusa 4	32
Pusa 12	5
Pusa 52	35
Pusa 80-5	2

Oats (*Avena sterilis* Linn.). Three selections, *viz.*, 12-1, 14-2 and 19-1, were tried this year against Pusa Farm oats under farm conditions, and the results of the experiment indicated that the Botanical Section selections were definitely superior in yielding power to the Pusa Farm oats. Quarter-acre blocks of each of these types, replicated eight times, were sown in the Punjab Experimental Field. The Botanical Section selections proved superior in nearly all cases as well as in the average. This was further confirmed by another set of experiments conducted by the Imperial Agriculturist, in the Brickfield, where one-acre blocks of each were sown side by side in long strips. The yield of grain obtained is shown below :—

Statement showing the yield of oats in Punjab Experimental Field, 1927-28.

B. S. 12-1		B. S. 19-1		B. S. 14-2		Pusa Farm	
Plot	Yield	Plot	Yield	Plot	Yield	Plot	Yield
	lb.		lb.		lb.		lb.
2 B	2,234	24 A	1,642	23 A	1,478	3 B	1,255
7 B	1,757	1 B	1,782	4 B	2,102	6 B	1,585

Statement showing the yield of oats in Punjab Experimental Field, 1927-28—concld.

B. S. 12-1		B. S. 19-1		B. S. 14-2		Pusa Farm	
Plot	Yield	Plot	Yield	Plot	Yield	Plot	Yield
	lb.		lb.		lb.		lb.
3 D	1,068	8 B	2,505	5 B	1,757	2 D	616
8 D	1,807	1 D	788	4 D	1,445	7 D	1,191
12 D	1,281	6 D	862	5 D	854	9 D	1,938
15 D	1,224	13 D	1,659	16 D	1,215	14 D	1,273
17 D	1,495	19 D	1,445	18 D	1,527	20 D	1,043
22 D	1,330	24 D	1,692	23 D	1,519	21 D	1,215
Total .	12,196		12,375		11,897		10,116
Average outturn per acre	1,524		1,547		1,487		1,264

Yield of oats per acre in Brickfield II, 1927-28.

B. S. 12-1	B. S. 19-1	B. S. 14-2	Pusa Farm (Average of 11 acres)
lb.	lb.	lb.	lb.
1,599	1,484	1,583	1,265

Comparing the yields of 12-1 with "Pusa Farm" in 7 paired plots in the Punjab Field and applying "Student's method" of estimating the significance of the difference between two sets of results, it is found that the odds are 76 : 1, and that the difference in yields is significant of a higher yielding power in 12-1.

Although 14-2 is the earliest maturing selection with a comparatively high yielding power, it has been finally rejected this year owing to its having a tendency to lodge badly. Further work will now be limited to 12-1 and 19-1 of these selections and these in future will be termed B. S. Type 1 and B. S. Type 2 respectively. In the coming season these will be tried again by the Imperial Agriculturist on a much larger scale and if they keep up their superiority, they will be released in the near future for seed distribution purposes.

The F_2 generations of two crosses made between the Scotch Potato oat and two Pusa selections were studied during the season and some very promising hybrids have been secured. The good grain and straw quality together with the heavy tillering power of the imported varieties have been combined with the earliness and disease resistance of the Indian parent, and when some of the types are fixed, a very great improvement in oats for Indian soils and climates will be achieved. The F_1 generation of another cross between Abundance and a Pusa selection was also studied.

Another European variety, Orion, belonging to the *Avena sterilis* group, was imported during the year under review, but it arrived nearly 3 weeks too late. It has, therefore, not done very well this year but has given indications of being a superior oat with an early habit and profuse tillering capacity, and if sown in the proper season may prove a useful type. Experience has proved that in this country early ripening is essential and that no selection, however heavy yielding, is likely to be popular in the long run, unless it is comparatively early ripening. All other improved varieties which have been tried in this Section, *viz.*, Abundance, Victory, Yielder, New Harvester, White Cluster, Scotch Potato, Gopher, Kanota, Iowa 103 and 105, Iowar 670 and Nebraska 21, are all much too late and seem to have no future in Bihar. By the time they come into flower west winds set in and dry up the plants before any normal setting can take place. By sowing these varieties a month or even 6 weeks before the general sowing time, no improvement was effected.

The cultivated oats in India belong to the species *Avena sterilis* Linn., sub-species *culta*, and not to *A. sativa* Linn., as has been believed and reported in all important Indian floras and other books of reference. Samples obtained from different parts of India showed the *sterilis* characters. A number of samples from Pusa selections together with some taken from the imported varieties of *A. sativa* were sent for identification to the Royal Botanic Gardens at Sibpur (Bengal) and Kew (England). A similar diagnosis to that made in this Section was made at Kew, confirming the fact that the Indian types belonged to the *A. sterilis* group. All Indian floras published to date state that the cultivated oat in India belongs to *A. sativa ;* this is evidently incorrect and a short article is being published on the subject.

Barley (*Hordeum vulgare* Linn.). A varietal trial of 21 pure line cultures of barley was repeated this year in small blocks $4' \times 50'$, each replicated 4 times, and the more promising forms will be tried on a larger scale next year. A tentative classification of the types isolated has been made. Some new samples have also been collected from cultivators' fields in important barley-growing districts in the United Provinces of Agra and Oudh and the Punjab and these will be com-

pared with our existing types. Some biometrical data has also been accumulated and a study of F_1 generation of crosses was made.

An attempt was made last year to hybridize Pusa 4 wheat with hulled and hull-less barleys and a few seeds of each were obtained. These were sown this year and a number of them germinated giving—

8 plants of Ramdana (hull-less) barley × Pusa 4 wheat;
2 plants of 23-10 (hulled) barley × Pusa 4 wheat;
and 7 plants of Pusa 4 wheat × 23-10 (hulled) barley.

All the plants, however, were very weak and sickly from the very start. The foliage resembled that of the barley parent more or less, excepting for the presence of a few hairs on the auricles (a wheat character) in some cases. The plants were nursed with the greatest care, but unfortunately none of them survived till the flowering season.

Maize (*Zea Mays* Linn.). The work of previous seasons has reduced the number of selections to two which were given an ear-to-row test in 1926. In this test the progenies of cob No. 2 in the yellow seeded type and of cob No. 9 in the white seeded type proved superior to all others and the reserve seed of these cobs was used to continue the work in 1927. Two hundred and eight plants of each type were raised and in this population the 50 best plants of each type were selected for comparison in yield. The average seed weight per plant in the 50 best plants was considerably less than that of the previous season; this low yield is to be attributed to the scanty rainfall during August and September. The five best plants in each set of fifty were selected for further trial and selection and seed from the remaining plants will be used for growing on a large scale in a yield test in comparison with an ordinary local variety.

The study of the effect of inbreeding in maize was continued and further degeneration as regards the height of plants took place in the progenies of selfed plants. In contrast with cultures which had been self-pollinated, cultures in which controlled cross-pollination between different plants of the same culture had been carried out were markedly vigorous. Plants in these latter cultures were taller than those in the selfed cultures and observations on the height of plants showed that little or no degeneration had taken place in progenies of controlled cross-pollinated cultures.

Statement showing the average seed-weight per plant in the progenies of 1926 and 1927.

Description of variety	Average weight of seed per plant in grm.	Frequency distribution for the seed-weight per plant											Total no. of plants
		61 to 80	81 to 100	101 to 120	121 to 140	141 to 160	161 to 180	181 to 200	201 to 220	221 to 240	241 to 260	261 to 280	281 to 300	
White seeded variety—														
For 50 selected plants in 1927 .	160	..	5	1	7	11	11	5	7	2	1	..	..	50
For the whole progeny in 1926 .	206	..	1	1	1	1	11	4	4	5	5	6	1	40
Yellow seeded variety—														
For the 50 selected plants in 1927.	148	1	4	9	6	9	10	8	3	..	..	..	..	50
For the whole progeny in 1926 .	193	..	1	1	4	1	7	9	12	1	6	..	1	43

All the necessary sowings were successfully carried out in 1928.

Tobacco (*Nicotiana Tabacum* Linn.). The third hybrid generation of selections from the F_2 populations of the crosses between Type 28 and Adcock and Burley were raised and studied. Two hundred and seventeen cultures were grown and examined with special reference to their capacity to produce a bright cigarette tobacco. The qualities required in the leaf are thinness, small mid-rib and veins and as a result a small amount of woody tissue, and the capacity to " yellow off " in the early stages of curing in the barn. Among the 217 cultures which were examined, 161 were rejected as they were obviously still segregating into different types, and among the remainder 18 cultures showed promise of giving a leaf of the required quality. The best of these will be tested during the coming season and the number of selections still further reduced.

The burning and smoking tests carried out in 1927 with the leaf produced in the season 1926-27 served to emphasize the importance of " ageing " in any estimation of the quality of Adcock leaf. " Ageing " in tobacco is a process akin to maturing in wine and is the term used to describe the changes which take place in the leaf in storage, after curing and the first fermentation in bulk are completed. During " ageing " a second and slow fermentation takes place which mellows the leaf, removes its rawness and bitterness, evens the colour and develops aroma. It appears probable that, under the conditions of high temperature and humidity which prevail in India in the months following the packing of tobacco into hogsheads, the fermentation during " ageing " is especially active and plays a more important part in the production of good tobacco than is the case in more temperate climates. Thus when the first cigarettes from the Pusa Adcock crop of 1926-27 were manufactured in June 1927, they were very disappointing in burning qualities and aroma. A second batch, however, was manufactured from the same leaf in December 1927, by which time the leaf had been in store for 9 months, and proved of excellent quality. The results of burning and smoking tests on the 1926-27 crop, therefore, show that cigarette leaf tobacco of a quality superior to any produced in India before can be obtained by flue-curing Adcock tobacco.

During the year under review, 2 acres of Adcock tobacco were grown in the Botanical Section at Pusa and the produce was flue-cured. Special attention was paid to the economics of the process with a view to obtaining an estimation of the cost of flue-curing in relation to the market price of the leaf. The results obtained together with a description of the method of cultivating and flue-curing Adcock tobacco are being published as a bulletin, and it is sufficient to say that the ratio of cost to price shows a satisfactory profit to the grower. The leaf produced during the season 1927-28 is now in store and the process

of "ageing" is being studied. Samples of Adcock leaf produced at Pusa during the past season have been submitted to expert opinion in the tobacco trade in England and have been described as "the best we have seen so far of Indian growth, being the nearest approach to the corresponding American type." Another opinion stated that "This type shows considerable improvement on the bright Indian leaf we have seen in the past. It has a thin stem but good colour. Bearing in mind, however, that the market is over-stocked with Rhodesian tobacco, it is doubtful whether supplies of your tobacco would be absorbed at higher prices than 9*d*. or 10*d*. but this was before Rhodesian was sold around these figures. We think, however, that when the market becomes more regular, there would be a good prospect for Indian tobacco similar to the Adcock type as it is improbable that Rhodesian could compete owing to the lower cost of production in India. At the same time, South Africa is also exporting a considerable quantity of tobacco and the cost of production in South Africa is probably well under Rhodesia. Nevertheless, we think, in spite of this, that the ultimate future for Indian tobacco similar to the type is good."

The tobacco market in the United Kingdom is at present overstocked with Empire grown leaf and prices are in consequence abnormally low. There is, however, no prospect of any large export of fluecured tobacco from India at present and by the time that such exports become possible this condition will have adjusted itself. While, however, the development of the export leaf tobacco trade from Empire territories to the United Kingdom has been stimulated by the grant of a preferential tariff to Empire grown leaf we must not forget that for a good quality cigarette leaf grown in India there is a ready market in this country. At the present moment the duty on unmanufactured leaf tobacco imported into India is Rs. 1-8 per lb., and during the year 1926-27, $5\frac{3}{4}$ million lb. were imported into India of which 95 per cent. came from the United States of America. It is obvious that if these imports could be replaced wholly or even in part by the home grown leaf a considerable saving would be effected. The amount of the saving would depend upon the ratio between the price paid for the imported leaf *plus* the amount of the duty and the cost of producing the home grown leaf in India; under present conditions there would be a heavy balance in favour of the Indian grown leaf.

Oil-seeds. The study of the inheritance of characters in linseed (*Linum usitatissimum* Linn.) was continued with the third hybrid generation of the crosses between Pusa linseeds which have been mentioned in previous annual reports. The observations on the third hybrid generation have confirmed the conclusions reached last year and have elucidated several difficult points which had been noted in the study of the F_2 population. The inheritance of colour in the petals

has been completely worked out and depends upon the segregation and interaction of about six different factors. The inheritance of colour in the filaments, anthers, style and stigma has also been worked out; the chief difficulty here is the variation in colour in these organs at different times of the day and in different intensities of light. The brown seed colour of the Northern Indian types appears to depend on two complementary factors one of which plays a part in the inheritance of flower colour. Special attention has been given to the inheritance of the seed characters as the investigation has for its economic object the isolation of a bold-seeded linseed with the vegetative system and root system which is suited to the Gangetic alluvium. Many plants which appear to possess the desired characters have been selected in the F_3 population and will be studied next season. Some new crosses have also been made which are likely to throw light on difficult cases in the previous crosses; the second hybrid generation of these new crosses will be studied next year. The new type of linseed, Type 124, has maintained its superiority over Type 12 and Type 121 as regards oil content. The results of the analyses made by the Imperial Agricultural Chemist, Pusa, during the past three seasons are as follows :—

Oil content percentage in linseed

Linseed Type	1928	1927	1926
12	37·96	39·39	38·94
121	42·32	41·07	41·77
124 (New Type)	42·65	40·91	42·05

The study of unit species of safflower (*Carthamus tinctorius* Linn.) was continued and will be completed next season. Two spineless types have proved useful as fodder crops and provide a useful substitute for other fodders when the latter are not available.

The isolation of types of sesamum (*Sesamum indicum* DC.) was continued. The study of the different cultures grown last year showed that many were identical and hence the number of cultures will be reduced in the coming season. The change of the normal variety into the sepaloid form was almost absent in the past season; this suggests that this phenomenon may be due to physiological causes rather than to the segregation and inheritance of genetic factors.

Rahar (*Cajanus indicus* Spreng.). The work of isolating the unit species in this crop was continued. Among 76 pure types, which have been already obtained, 12 of the most promising were grown on a field scale to test their yielding power. As the classification of types has

not yet been completed, these 12 types are provisionally known under letters A, B, C, etc.; they were grown with maize and the yields are shown in the statement on pages 11-12. It must be noted here that the damp cloudy weather in January and February was very unfavourable to seed setting both in *rahar* and gram and hence yields in both these crops are lower than usual. An analysis of the seed of these 12 types was made by the Imperial Agricultural Chemist and shows considerable variation considering that all the different types were grown within the relatively small Botanical Area. It appears that the morphological differences between types are correlated with physiological differences in their metabolism.

Analysis of types of Rahar.

No. of sample of rahar	Moisture	Ether Extract	Crude proteids	Soluble carbo-hydrates	Woody fibre	Soluble mineral matter	Sand	Total organic nitrogen	Albumi-noid nitrogen	Albumi-noid ratio
A	8·61	1·15	20·49	59·27	6·35	4·09	0·04	3·28	3·06	3·24
B	8·45	0·79	19·50	58·13	9·36	3·75	0·02	3·12	2·73	3·52
C	8·06	0·83	21·36	56·91	8·98	3·85	0·01	3·42	3·08	3·06
D	8·72	1·29	21·76	57·39	6·96	3·82	0·06	3·48	3·25	2·97
E	8·38	1·08	16·71	61·35	8·73	3·74	0·01	2·67	2·54	4·02
F	7·87	1·16	18·96	60·79	7·42	3·77	0·03	3·03	2·80	3·63
G	7·35	1·04	21·03	59·19	7·35	4·01	0·03	3·36	3·12	3·16
H	8·18	1·08	18·58	59·81	8·48	3·86	0·01	2·97	2·78	3·59
K	7·85	0·87	18·41	61·03	7·90	3·93	0·01	2·95	2·74	3·69
M	7·91	1·17	18·93	61·14	7·08	3·74	0·03	3·03	2·79	3·66
P	8·26	1·25	18·13	61·72	6·87	3·71	0·06	2·90	2·67	3·88
R	7·11	0·78	17·30	61·99	8·97	3·84	0·01	2·77	2·56	3·98

The work on unit species in *rahar* stands in close relation to the research on the isolation of a type of *rahar* which shall be resistant to wilt disease. This latter investigation is carried on in collaboration with the Imperial Mycologist, Pusa, and is nearing completion. The behaviour of several of the types, which have been isolated in the work on unit species, with reference to wilt disease has thrown considerable light on the correlation between the presence of certain morphological characters and the possession of resistance. Crosses have been made with the object of investigating the inheritance of resistance and the first hybrid generation is now growing in the Botanical Area.

Gram (*Cicer arietinum* Linn.). The study of new unit species of this crop was continued and will be completed very shortly. The new types have been isolated from seed collected from all over India and make an important addition to the original 25 Pusa Types of gram which were isolated from seed obtained from Aligarh, Muzaffarnagar and Saharanpur Districts of the United Provinces of Agra and Oudh and from a small area round Pusa.

The study of the inheritance of characters in gram from the cross between Type 2 and Type 18 has provided very interesting results and observations made on the third hybrid generation have elucidated several points which were obscure in the F_2 population. The original observation in the F_2 population, that red colour in the flower and stem was dependent on a single factor, was confirmed in F_3 and it was found that this factor is linked with a factor for seed colour. The inheritance of seed colour and shape appears to depend on the segregation and interaction of four factors, the same factors which determine colour in the seed being also responsible for shape in the seed. In this way the close correlation between seed colour and seed shape can be explained. Many new types of gram seeds have been isolated from this cross and some show promise of being of economic importance. The interpretation of observations in the F_2 and F_3 populations on the basis of the segregation and interaction of 4 factors, especially in view of the linkage between flower colour and seed colour and between seed colour and seed shape, has proved a very complex problem in Mendelian inheritance and great credit is due to Mr. Mahbub Alam, one of the post-graduate students, for the part which he has played in this investigation. The quantitative inheritance of certain size characters has been studied. The size of leaf, size of standard, size of pod and size of seed are characters in which the two parents differ widely from one another. The inheritance of these size characters, according to our observations on F_2 and F_3 populations, can be explained on a basis of cumulative factors in accordance with Mendelian theory. Correlation appears to exist between certain qualitative characters and some quantitative charac-

ters ; thus white flower colour is associated with lower values for the leaf index and red flower colour with higher values.

The F_2 population of the cross between Type 1 and Type 25 was also studied during the year under review. The inheritance of colour in the flower in this cross is more complicated than in the previous cross. So far as the inheritance of pink colour is concerned, we find that this is determined by a single factor difference as in the previous case. The flower colour in Type 1, however, is not white but is greenish-white and the inheritance of this green colour appears to be determined by the segregation of two factors in addition to the factor for pink colour. The inheritance of colour in the seed appears to be due to the segregation and interaction of 3 factors and it is probable that these same factors also determine the seed shape. Observations on the F_3 population during the coming season will throw light on these hypotheses. The inheritance of quantitative characters is also being studied in this cross.

Peas (*Pisum sativum* Linn., and *Pisum arvense* Linn.). A classification of types of Indian peas which have been isolated at Pusa was made and will be completed during the coming season. The study of some crosses between *P. sativum* and *P. arvense* was continued and the third hybrid generation from these crosses will be raised next season.

Sugarcane (*Saccharum officinarum* Linn.). The 13 best canes selected last year for further trial on field scale were handed over to the Imperial Agriculturist for multiplying in the cane nursery area on Pusa Farm (New Area). These were multiplied according to the setts available and their progenies were observed in different characters. Seven chemical analyses were made of the canes of each progeny on different dates by the Imperial Agricultural Chemist. The results obtained were as follows :—

Chemical analyses of the canes.

No. of cane	Average weight of a cane in lb	In Juice												
		Brix corrected							Percentage of sucrose					
Dates	7-1-28	22-10-27	8-11-27	25-11-27	12-12-27	7-1-28	23-1-28	8-2-28	22-10-27	8-11-27	25-11-27	12-12-27	7-1-28	23-1-28	8-2-28
	lb.														
1	1·27	..	17·33	17·44	18·01	18·67	19·07	19·33	11·84	15·05	15·19	16·59	16·45	17·75	17·70
2	1·15	..	19·13	20·39	19·81	21·12	21·52	20·98	13·33	16·42	18·73	18·23	19·05	19·76	18·39
3	2·45	..	17·98	17·93	18·73	18·67	18·16	18·95	11·45	14·59	14·43	16·62	15·87	15·09	15·59
4	1·47	..	17·71	18·85	20·07	20·49	20·93	21·20	12·01	14·61	16·40	18·31	18·43	18·98	19·08
5	1·99	..	17·53	17·70	19·63	19·37	19·59	20·53	10·42	14·41	14·72	17·75	17·22	17·69	17·68
6	2·31	..	17·29	17·24	17·58	18·47	18·80	18·71	12·15	14·20	14·04	14·96	15·72	15·85	16·19
7	1·35	..	18·17	20·20	20·10	20·71	19·14	20·98	12·70	16·38	18·62	18·46	19·72	17·93	19·18
8	1·38	..	19·09	19·41	20·56	21·23	20·37	21·68	14·17	16·38	17·05	18·63	19·86	18·55	20·19
9	1·16	..	20·00	21·64	22·77	22·33	22·35	21·15	17·59	18·47	19·95	21·42	21·40	21·22	20·29
10	1·69	..	19·35	20·08	20·33	22·11	21·69	22·03	15·77	16·59	17·84	17·70	20·06	20·11	20·11
11	1·78	..	18·01	18·49	20·10	20·87	21·25	22·03	12·97	15·17	16·59	17·86	19·07	19·42	20·32
12	1·43	..	17·52	16·89	18·76	18·30	19·47	20·03	12·47	14·87	14·44	16·81	16·53	17·45	18·34
13	1·13	..	17·71	19·63	20·33	21·15	20·65	20·71	13·87	14·83	16·64	17·72	18·62	18·63	18·51
Co 213 Farm	2·48	..	15·17	17·94	19·54	18·65	19·53	20·86	10·78	11·31	15·36	17·50	16·52	17·55	18·79

No. of cane	Average weight of a cane in lb.	In Juice												
		Percentage of Glucose							Purity					
Dates	7-1-28	22-10-27	8-11-27	25-11-27	12-12-27	7-1-28	23-1-28	8-2-28	22-10-27	8-11-27	25-11-27	12-12-27	7-1-28	23-1-28	8-2-28
	lb.														
1	1·27	1·69	1·14	1·14	0·67	1·01	0·49	0·61	80·93	86·83	87·10	92·11	88·11	93·05	91·59
2	1·15	1·81	1·26	1·03	0·78	0·73	0·75	0·98	84·16	85·83	91·84	92·02	90·21	91·84	87·63
3	2·45	2·37	1·95	1·79	0·88	1·25	1·11	0·77	76·70	81·16	80·52	88·76	85·03	83·08	82·29
4	1·47	1·97	1·51	1·19	0·44	0·47	0·46	0·22	79·30	82·47	86·99	91·25	89·93	96·69	90·09
5	1·99	1·90	1·56	1·30	0·58	0·49	0·30	0·81	74·43	82·21	83·14	90·44	88·90	90·31	86·13
6	2·31	2·14	1·80	2·34	1·14	1·29	1·41	0·79	78·04	82·11	81·43	85·12	85·10	84·33	86·52
7	1·35	1·39	0·97	0·57	0·40	0·21	0·20	0·24	81·35	90·14	92·21	91·83	95·20	93·70	91·43
8	1·38	1·31	1·01	1·08	0·53	0·29	0·56	0·39	85·65	85·79	87·82	90·60	93·57	91·06	93·13
9	1·16	0·93	0·63	0·36	0·32	0·27	0·16	0·11	88·28	92·36	92·17	94·09	95·81	94·95	95·94
10	1·69	2·12	1·16	0·87	0·89	0·47	0·48	0·40	88·23	85·73	88·84	87·08	90·71	92·73	91·30
11	1·78	1·81	1·51	1·06	0·68	0·65	0·43	0·31	79·53	84·24	89·75	88·88	91·37	91·38	92·22
12	1·43	2·14	1·42	0·98	0·73	0·66	0·40	0·27	78·95	84·87	85·49	89·61	90·34	89·62	91·54
13	1·13	1·80	1·56	1·22	0·96	0·88	0·61	0·52	79·59	83·76	84·77	87·18	88·03	90·24	89·37
Co. 213 Farm.	2·48	2·06	1·58	0·86	0·75	0·47	0·27	0·15	75·96	74·58	85·61	89·55	88·59	89·87	90·07

Canes Nos. 4, 7, 8, 9, 10 and 11 showed a higher sucrose content throughout than Co. 213 (Farm); Nos. 2, 5, 12, and 13 also seem quite good. In growth Nos. 3, 4, 5, 6 and 11 were the best.

Canes Nos. 3, 4, 5 and 11 were selected for trying on a field scale in comparison with Co. 213, and these are now growing in the Brickfield of the Pusa Farm. The other promising varieties could not be tried on a large scale because enough setts were not available. All except those grown on a field scale were again sown in the nursery area of the farm for multiplication and are now growing there.

Two new varieties were also selected from the second batch of the seedling canes. These were handed over to the Imperial Agriculturist for multiplication and testing in the nursery area.

Hemp (*Cannabis sativa* Linn.). Selfed seed was raised from a single plant of culture H-17 of last year, this being the culture which showed the least tendency towards monoeciousness. Seed from suitable plants has been kept for future work on the study of the effect of external stimuli on the sex-ratios of Indian hemp. Some seed from this was also supplied to the Director of Agriculture, Madras, who is trying to select good Ganja types for his tract.

Lentils (*Ervum lens* Linn.). Sixty-six types of lentils have been isolated from mixed samples collected from different parts of India and the result of a systematic study of this crop is published. Variety yield tests of the more promising types will be taken up in the future.

Mung (*Phaseolus mungo* Linn.) and *Urid* (*Phaseolus radiatus* Linn.). Work on the selection of pure line forms of these crops is being continued. Suitable soil for these crops, unfortunately, is not available in the Botanical Area, and hence they suffer here a good deal owing to unfavourable soil conditions. A study of the root system of *urid* and *mung* has also been commenced.

Chillies (*Capsicum annuum* Linn.). The isolation and classification of the Indian types of *Capsicum* has been completed and a publication is in the press. Fifty-two different types have been separated and some of them will be tested for yield in the next season. A study of the inheritance of characters has been commenced and crosses between certain types were made; the first hybrid generation will be grown next season. An investigation of the root systems will be made during the study of the crosses and the yield trials.

III. Publications and Programme.

Publications.

Shaw, F. J. F. . .	Summary of the Progress of Research in Agricultural Botany for the year ending 31st March, 1928, for inclusion in the Report for the Privy Council.
Shaw, F. J. F. . .	The Imperial Agricultural Research Conference. *Agri. Jour. of India*, Vol. XXIII, Part II, 1928, pp. 73-79.
Shaw, F. J. F. . .	India and the Leaf Tobacco Trade of the British Empire. *Agri. Jour. of India*, Vol. XXIII, Part IV, 1928, pp. 267-270.
Shaw, F. J. F., and Khan Sahib Abdur Rahman Khan.	Studies in Indian Chillies. (1) The Types of Capsicum. *Mem. Dept. of Agri. in India, Bot. Series*, Vol. XVI, No. 2.
Shaw, F. J. F., and Kashi Ram.	The Production of Cigarette Tobacco by Flue-Curing. *Agri. Res. Inst., Pusa Bull. No.* 188.
Shaw, F. J. F., and Rakhal Das Bose.	Studies in Indian Pulses. I. *Ervum lens* Linn. *Mem. Dept. of Agri. in India, Bot. Ser.*, Vol. XVI, No. 6.
Khan Sahib Abdur Rahman Khan.	Defective Bearing in Plum. *Agri. Jour. of India*, Vol. XXIII, Part II, 1928, pp. 134-136.

Programme for 1928-29.

Investigations will be continued on the lines indicated in this report on the following crops—wheat, barley, oats, maize, tobacco, chillies, pulses, hemp, gram, linseeds, *rahar*, peas, etc. Experiments in the curing of tobacco and on the incidence of wilt disease in *rahar* will also be carried out. The training of students will proceed as in past years.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(W. H. Harrison, D.Sc.)

I. Administration.

Dr. W. H. Harrison held charge of the Section throughout the year.

Dr. J. Sen, who had been on deputation to the Forest Research Institute as Bio-chemist, joined duty in this Section as Plant Biological Chemist on 10th April, 1928.

Mr. P. B. Sanyal officiated as First Assistant from 29th August to 29th September, 1927, during the absence on leave of Mr. J. N. Mukerji.

II. Education.

Mr. Sher Singh Mangat, M.Sc., completed his course of training in September 1927. Mr. Barindranath Pal, M.Sc., and Mr. P. N. Vridhachalam were admitted to the post graduate course, but the former resigned in January. Mr. P. N. Vridhachalam is continuing his studies.

III. Meteorology and Drain-gauges.

The usual meteorological and drain-gauge records were maintained. The crops and 56 samples of drainage waters from the gauges were examined in the usual manner.

IV. General analytical work and assistance given to other Sections.

A. The following samples were analysed and reported upon :—

Soils	18
Manures	12
Feeding stuffs	21
Oil-seeds	3
Gur	1
Sugarcane	375
Sugar beet	2
Milk	2,567
Waters	8
Sewage	3
Miscellaneous	1
Total	3,011

Six samples of soil, six of well waters, three of sewage and six of feeding stuffs were received from the Baroda State ; two samples of soil

were received from the Patiala State and a sample of gypsum from Bikanir. Two samples of water were sent by the Irrigation Officer, Baluchistan, and samples of sugar beet were analysed at the request of the Agricultural Officer, North-West Frontier Province.

The sample of *gur* was stated to have come from Thibet, having been imported from China. It was exceedingly hard and was superior to the ordinary *gur* of Northern India.

B. The following assistance was rendered to other Sections :—

Agricultural Section. 8 samples of manures, 375 of sugarcane and 2,567 samples of milk were examined.

Botanical Section. 3 samples of oil-seeds and 15 samples of feeding stuffs were analysed.

Entomological Section. A sample of gum excreted by *ber* (*Zizyphus jujuba*) trees after lac inoculation was examined.

V. Research.

1. *The effect of manurial constituents on the quality of sugarcane juice and gur.* This investigation was continued during the year under report with Co. 213 cane. In addition to the separate manures employed last year, combinations of superphosphate, sulphate of potash and sulphate of ammonia were employed and their effects studied.

The manures were applied in two doses and healthy canes were analysed periodically. Owing to climatic variations, the growth was much more vigorous than in the previous year and lodging occurred to a greater extent. The canes too did not fully mature although left in the field until the end of February, whereas in the previous year ripeness was attained at the end of January. *Gur*-making was started on 1st March when the glucose content of the juice from most of the plots was between 1 and 1·6 per cent.

(*a*) *Effect of separate manures.* The results obtained confirm, in general, those of the previous year. Potash manuring yielded juices which from November to February had the highest co-efficient of purity and contained the largest amount of sucrose and the lowest of glucose. Sulphate of ammonia, on the other hand, yielded the lowest values for purity and sucrose and the highest for glucose. Superphosphate gave results somewhat different from those obtained previously which closely followed those of potash. This year superphosphate was inferior to potash but superior to sulphate of ammonia and in fact closely followed the graphs for mustard cake. The effect of mustard cake again showed it to be superior to cyanamide or sulphate of ammonia, particularly in the later stages of growth.

Cane grown without any manure gave juices which were inferior in quality to those produced by potash, but in all cases they were superior

to the juices produced by the other manures. The yield of cane like that of the potash plots was decidedly low.

(*b*) *Effect of mixed manures.* Four combinations were under observation, namely, (1) sulphate of ammonia and superphosphate, (2) sulphate of potash and superphosphate, (3) sulphate of ammonia and potash, and (4) a combination of all three manures.

Throughout the period November to March, the canes manured with potash and super yielded juices of the highest quality, whereas, those of lowest quality were produced on the plots treated with a combination of sulphate of ammonia and potash. Again, the combination of superphosphate and ammonia gave better quality juice than the sulphates of potash and ammonia combination, and also better than the complete combination. Superphosphate, therefore, when used in combination with ammonia, counteracts the depressing effect of the latter, whereas potash would appear to accentuate it.

Although superphosphate combined with sulphate of potash gave the highest quality, the yield was markedly low. From this point of view, the best combination was superphosphate and sulphate of ammonia.

A more detailed series of experiments has been laid down for the present season.

2. *Adulteration of butter and ghee with animal fat.* In last year's report it was stated that it had become necessary to examine the butter produced by cows and buffaloes fed on different concentrates, and, in particular, to examine the effect of cotton seed. Mr. Sanyal has been enabled to undertake this investigation through the courtesy of the Departments of Agriculture in Madras, Bombay, Bengal, Central Provinces and Baroda State, and has found that in regard to cow's butter and *ghee*, the test for adulteration which he has evolved is effective even when the ration contains cotton seed ; and this applies to butters and *ghees* produced by buffaloes which do not receive cotton seed in their ration.

In the case of buffaloes receiving a ration of cotton-seed, the test gives a definite precipitate as evidently the composition of the milk fats is altered by this food-stuff and for this reason many commercial samples of butter would be suspected if the original test were adhered to.

The original test referred to consists in dissolving exactly one gramme of dry butter fat in 3 c.c. anhydrous acetic ether and then adding 4 c.c. of 93 per cent. alcohol. The mixture is then maintained at a temperature of 30° C. for half an hour when the formation of a precipitate indicates adulteration with animal fat. This test is effective for all cow butters and any buffalo butter from animals not fed on cotton-seed, and butters passing it satisfactorily may be considered free from adulteration with animal fat.

Butters which do not pass this test must then be subjected to a another test in which one gramme of the fat is dissolved in 4 c.c. anhydrous acetic ether and then to this solution is added 3 c.c. of 93 per cent. alcohol and the whole maintained at 30° C. for half an hour. Under these conditions all butters from buffaloes fed on cotton-seed are shown to be genuine, whereas the addition of 10 per cent. animal fat, even to cow's butter, gives a positive reaction.

A large number of commercial butters purchased in different parts of India have been examined and little evidence of adulteration has been obtained.

The detection of added " vegetable fat " presents difficulties as test I will detect a 10 per cent. addition of such samples as we have been able to procure, whereas test II would not detect an addition of 50 per cent. In these cases, however, an abnormal iodine value was obtained which clearly indicated an admixture.

3. *Experiments on the curing of tobacco.* Mr. Mukherji has continued his investigations on the efficacy of different methods of curing tobacco and their effect on the composition of the leaf and, in particular, the changes which occur during the process of curing. Acting on the report of the Indian Tobacco Development Co. on the previous year's results, attention this year was limited to the following methods :—

1. Curing on the ground in the sun but protected from dew for the first 8 days.
2. Curing on racks with exposure to both sun and dew.
3. Curing on racks in the sun but with protection from night dews.
4. As in No. 2 for the first three days, after which as in No. 3 for 10 days and finally cured in the shade.
5. Curing in shade for the whole period.

The varieties of tobacco used in the experiments were Pusa T. 28, Adcock and White Burley.

The report of the Indian Leaf Development Co. declared Pusa T. 28 and Adcock cured by method (3) to be the best, followed in order of quality by the same varieties cured by method (4) and White Burley by method (3). All these varieties cured by method (5) were next in order.

The chemical examination of uncured leaves has shown that the country varieties of tobacco contain higher nicotine and starch contents than the American ones. Pusa T. 28 stands intermediate between the two so far as nicotine is concerned, but its starch content is as low as that of the American leaves. The upper leaves of the plants invariably contained more nicotine and starch than the lower ones.

Analysis of the cured leaves indicates littled iminution of nicotine, but there is a marked destruction of starch. It would also appear that

this destruction of starch during the curing process is related to "quality," being greatest in those samples declared to be best.

4. *Lime requirement of acid soils.* Mr. S. Das has continued his comparative study of the methods proposed by different workers for the estimation of the lime requirements of soils. Five acid soils from different parts of Bengal, Assam and Burma were selected and examined by fifteen different methods. The results showed that the values of lime requirement given by the different methods did not agree amongst themselves either in actual value or order of acidity except in the case of extraction with hydrolysed salts when the order of acidity remained the same, notwithstanding considerable differences in values. It is, therefore, extremely difficult to choose any of the methods for employment in practice until co-ordination with actual field results is obtained.

Further, it has been found that a variation in the concentration of the extracting liquids causes considerable changes in the lime requirement value obtained. The methods are obviously empirical in character depending simply upon an equilibrium relation between the soil and solvent.

5. *The estimation of the pH values of soils by means of the antimony electrode.* For sometime the Imperial Agricultural Chemist has been investigating the application of certain metallic electrodes as indicators for the determination of pH values. Of a large number of electrodes experimented with the antimony, one has proved capable of giving reliable and reproducible values over long periods. This has been known for some time, but little attention has been paid to its practical application in technology and none to its application to soils for the estimation of acidity and alkalinity.

Hitherto estimations of pH by this electrode have been made, whilst the liquid to be tested has been kept agitated, but it has been found that such estimations can be as well made with the liquid quiescent when a relation $pH = 20{\cdot}04\Sigma obs - {\cdot}469$

or $pH = \frac{\Sigma obs - {\cdot}0234}{{\cdot}0498}$ is obtained for electrodes made from Merck's extra pure antimony with a saturated calomel electrode as reference. Other brands of antimony give slightly different values approximating to the above.

On applying this electrode to soil extracts, values were obtained which were checked against those obtained by a hydrogen electrode, but the difficulty was to decide which of the latter could be taken as correct as the values obtained varied according to the method of preparing the soil extract particularly in the case of acid soils. It was, however, noticed that if the antimony electrode were placed in the moistened soil contained in a glass vessel having a porous bottom so that it could be connected by means of a saline bridge to the reference cell, definite

reproducible pH values could be obtained. These values were practically the same as those obtained by hydrogen electrodes in contact with an emulsion of the soil and very similar to those given by the extract obtained after settling a soil emulsion for 24 hours.

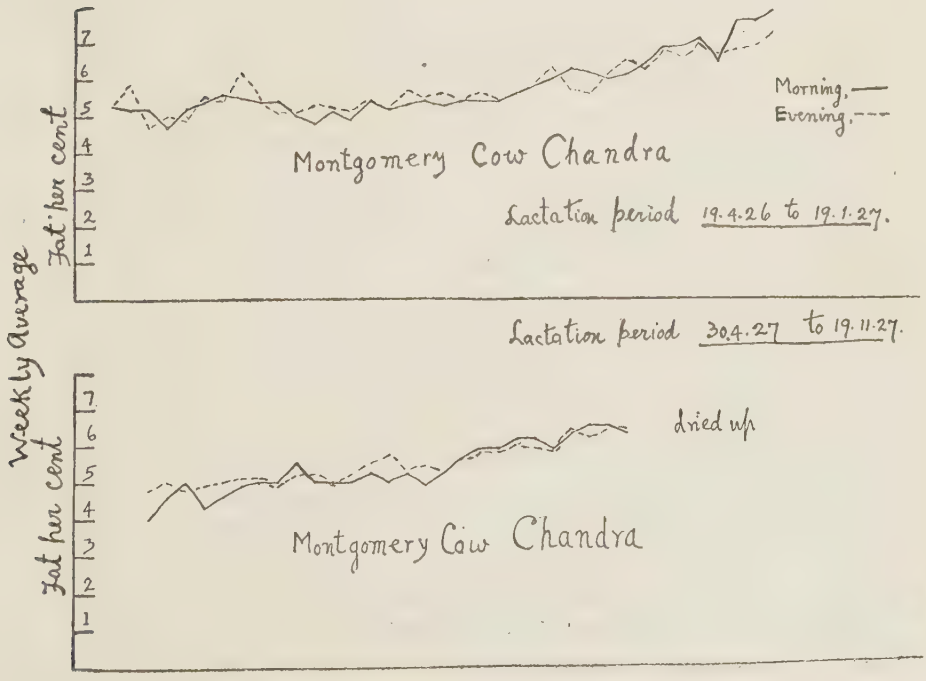
The antimony electrode employed in the manner described above is robust and reproducible and very suitable for application in the field either for soil surveys or for the study of changes *in situ*. A certain amount of work still remains to be carried out particularly in the direction of determining temperature corrections and when this is completed the results will be prepared for publication.

6. *Study of the variations of fat content in the milk of selected cows.* Four Montgomery and two Ayrshire—Montgomery cross-bred cows were examined during the period of their lactations. Of these, two of the Montgomery cows had been examined in their previous lactations also. From the data obtained, the following conclusions are drawn.

As observed in previous years, the milk towards the end of the lactation period is markedly enriched with fat.

Each cow tends to keep up an individual character in giving milk of similar fat content in her different lactations.

Two charts illustrating the above remarks are given below.



Investigations conducted by the Physical Chemist.

1. *Base exchange and soil acidity.* The experimental evidence adduced so far in this investigation lends support to the view that soil acidity is due to an insoluble colloidal acid or acidoid which is associated with surface active hydrogen and basic cations. Experiments with a number of soils showed that when a soil is exhaustively treated with $\frac{N}{20}$ HCl and washed free from the excess of acid, the amount of H retained by it is a characteristic constant for that soil. Further, this hydrogen can be replaced by any other electropositive ion by the exhaustive treatment of its neutral salt.

The total free acid thus produced, if titrated to phenolphthalein, is found to be chemically equivalent to the other ion taking the place of the H ions.

A number of reactions characteristic of soluble acids were studied on the insoluble colloidal acid (acidoid), contained in fully unsaturated soils, obtained by exhaustive treatment with $\frac{N}{20}$ HCl, and partly unsaturated natural soils. The outstanding facts that emerge from this study are that acidoid, though insoluble, shows reactions similar to those of soluble acids. These, however, take place in 3 distinct stages in which one, two, or three equivalents of H can take part, *i.e.*, H_1 H_2 and H_3.

H_1 is replaced by exhaustive treatment with a neutral salt; when this is replaced, the suspension is neutral (pH_7). H_1 is the only part that can invert sucrose, hydrolyse ethyl acetate, decompose ZnS, show " exchange " acidity or retain ammonia or amines at 100-105°C. When H_1 has been replaced in a soil, another equivalent of hydrogen (H_2) can take part in reaction with carbonates. After reaction with carbonates, it still contains another equivalent of hydrogen (H_3) that can neutralize alkalies. This last compound, however, is easily hydrolysed and the end point only be determined by having a large excess of alkali. The above experimental facts can be best interpreted by supposing that the acidoid in a fully unsaturated soil is a tribasic acid.

Acid soils are those in which a part or the whole of H_1 is free (the latter being an extreme case is seldom found in nature).

Alkali soils are those in which the whole of H_1 and a part of H_2 has been replaced or neutralized (the latter again, being an extreme case, is seldom found in nature).

Salts of H_3 being so easily hydrolysed are never found in nature, and so for all practical purposes we can leave it out of account.

2. *The effect of storing wheat grains at different humidities on their germination capacity.* Water being an essential constituent of germ cells, it seemed possible that seeds might respond to variations of moisture content especially if they are stored at a particular humidity for a long time.

Accordingly, two varieties of wheat—Pusa 4 and Pusa 12—were stored for six months at different humidities ranging from 10—85 per cent. controlled by sulphuric acid water mixture of appropriate concentrations. At the end of six months they were taken out and their germination capacity determined. Those at 85 per cent. humidity were all infested with fungus and were discarded.

The germination was visible on the third day when the counts were started. The results bring out some interesting points.

The optimum of germination occurred when the seeds were stored at 50 per cent. humidity, but the two varieties showed a marked difference. Pusa 4 is not so sensitive to the value of humidity at which it is stored and can stand a higher humidity much better than Pusa 12 which is very sensitive to variations of humidity at which it is stored

It is well known that Pusa 4 does well at places where tne humidity is high in the storing season; while Pusa 12 is more suitable for drier regions like the North of India. Further, it is known that Pusa 12 is softer than Pusa 4 and is likely to be affected by changes of moisture; and in fact at all humidities the moisture content of Pusa 12 is always higher than that of Pusa 4. It is possible that the moisture content at 50 per cent. humidity might afford a method of defining the degree of hardness or softness of a particular variety not only in the mechanical sense but as regards its general behaviour towards water intake at the time of germination. The work is being continued with other varieties.

3. *Movement of soil moisture in Pusa soils.* The object of this investigation was to see if there is any lateral movement of soil water due to crops.

The rectangular piece of land on which the moisture movement is being studied is 70×120 ft. Samples are taken once a month by nine borings up to a depth of 5 ft. Each of the 45 samples is analysed mechanically and its moisture content determined.

The work will extend over a period of at least two years and no definite conclusions can be offered at present, though there is indication that there is very little lateral movement of the soil moisture.

4. *Apparatus for testing the hardness of sugarcane rind.* An apparatus has been devised for testing the hardness of the rind of sugarcanes; and over 2,000 readings have already been taken with it by the Sugarcane Expert to the Government of India. The results are being written up for publication. The Sugarcane Expert hopes ultimately to be able to add readings for rind hardness as a definite character while selecting new seedlings for places liable to jackal trouble.

5. *Pot-culture experiments.* Pot-culture experiments have been started to find out why kidney beans (*Phaseolus aconitifolius*) do not grow in Pusa soil.

Three sets of experiments have been started :—

(1) The effect of adding increasing amounts of a Punjab soil to Pusa soil.

(2) The effect of different manures like potash, phosphate, farmyard and oil-cake.

(3) The effect of varying the moisture content of the soil on the growth of beans.

The results so far obtained can only be offered as tentative. It appears that moisture is the most important limiting factor and there seems to be an optimum of moisture and the crop appears to be very sensitive to departures from this optimum. If it is less, the plants show signs of wiltings ; if it is more, a peculiar condition is set up when the leaves curl, look flabby and droop down.

VI. Programme of work for 1928-29.

A. *Imperial Agricultural Chemist.*

1. Effect of manurial combinations on the quality of cane juice and the *gur* produced therefrom.

2. Composition of crops as affected by manurial treatment.

3. Variations in the composition of milk.

4. Study of the changes occurring in tobacco leaf under various methods of curing.

5. The employment of the antimony electrode for the determination of the pH value of soils and its application to field conditions.

6. A study of the methods for determining the lime requirements of soils.

B. Plant Biological Chemist.

1. To study the influence of organic matter on the soil.

2. To study the question of nitrogen recuperation in Indian soils.

3. To investigate the fixation of nitrogen by plants.

C. Physical Chemist.

1. Continuation of the work on soil acidity and base exchange.

2. Continuation of the work on the effect of storing wheat grains at different humidities on their germination capacity.

3. Continuation of the work on movement of soil moisture.

4. Pot-culture experiments and field trials in connection with the work on soil acidity and factors governing the growth of kidney beans in Pusa soil.

VII. List of Publications.

Harrison, W. H. . .	Report of the Progress of Agricultural Chemistry in India for the year 1927-28 for the Committee of the Privy Council for Scientific and Industrial Research, London.
Sen, A. T. . . .	The Determination of the Electrical Conductivity of the Aqueous Extract of Soil as a rapid means of detecting its probable fertility. *Mem. Dept. Agri. India, Chem. Ser.*, Vol. IX, No. 8.
Sanyal, P. B. . .	A Preliminary Note on the effect of Manurial constituents on the quality of Sugarcane Juice and *Gur*. *Agri. Jour. India*, Vol. XXIII, No. IV.
Puri, A. N., and Amin, Bhailal M.	A comparative study of the Methods of preparation of the Soil for Mechanical Analysis, with a Note on the Pipette Method. *Pusa Agri. Res. Inst. Bull.* 175.
Sen, J. . . .	The Composition of some Indian Feeding Stuffs. *Pusa Agri. Res. Inst. Bull.* No. 70 (Revised).

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST.

(N. V. Joshi, B.A., M.Sc., L.Ag.)

I. Administration.

Mr. J. H. Walton was in charge of the section till 30th April, 1928 when he went on combined leave for 6 months and 15 days and I held charge of the section for the remaining period of the year under report. I also held charge of the Section from 16th October to 2nd November, 1927, when Mr. J. H. Walton went on training with the Army in India Reserve of Officers.

Mr. N. V. Joshi, First Assistant to the Imperial Agricultural Bacteriologist, was on leave on average pay for 29 days from 8th March, 1928. Mr. C. S. Ram Ayyar, First Assistant to the Imperial Agricultural Bacteriologist (Industrial branch), acted in place of Mr. N. V. Joshi and Mr. Harihar Prasad, Laboratory Assistant, acted in place of Mr. C. S. Ram Ayyar.

Mr. C. S. Ram Ayyar, First Assistant to the Imperial Agricultural Bacteriologist (Industrial branch), was on combined leave for 2 months and 19 days, with effect from 11th July, 1927. Mr. Harihar Prasad, Laboratory Assistant, acted in place of Mr. C. S. Ram Ayyar.

Mr. S. V. Desai, Assistant to the Imperial Agricultural Bacteriologist, was on leave on average pay for 22 days from 12th October, 1927. Mr. Harihar Prasad, Laboratory Assistant, acted in place of Mr. S. V. Desai.

II. Training.

Mr. M. R. Madhoke, B.Sc., a post graduate student admitted in January, 1926, completed his course and was relieved from this section on the 26th October, 1927.

Two batches of students from the Institute of Animal Husbandry and Dairying, Bangalore, were given general lectures on the methods, aim and scope of agricultural bacteriology during March and May 1928. They were also given practical instructions in the methods of the bacteriological examination of milk.

III. Soil Biology.

Nitrogen fixation. The series of investigations on the fluctuations in the total nitrogen content of soils at Pusa was continued through-

out the year. Five plots of the permanent manurial experiments in the Punjab field were analysed for nitrate and total nitrogen to a depth of one foot every month. The samples of the top six inches of soil from each plot were incubated at 30°C. and the total nitrogen estimated again at the end of one and of two months, for comparison with the nitrogen content of the fresh samples. The nitrogen content in the control plot was highest in August. In the case of the plots treated with farmyard manure and green manure, the figures which were high in June tended to lower down during the rains and again rise in January 1928. In the case of superphosphate plot with the exception of a fall in November and December 1927, the figures were pretty high, the highest figure reached being in April. In the case of green manure and superphosphate there was no falling down from June to January, when there was a distinct rise which was more or less kept up to May. As in the previous year, the greatest amounts of nitrogen were found in plot No. 16-A (green manure and superphosphate). This was followed by plots No. 8-A (superphosphate), No. 3-A (farmyard manure) approximately equal and No. 12-A (green manure), and the lowest amounts were always found in plot No. 11-A which received no manure. These observations will be continued for some time next year.

The observations carried on with one of the plots in the experimental area of this section, showed slight variation in nitrogen in the fallow plot. Starting with a high figure in June 1927, there was a slight decrease which more or less kept constant till February, 1928, when there was a rise followed by a slight decrease. In the cropped plot starting with the high figure in June, there was a decrease which continued more or less till May, 1928.

Four series of observations were also carried out in the irrigated land, growing maize and berseem, in the Simri and Chandman dhab areas. Very wide fluctuations in the nitrogen content of the plots continued to be found, similar to those of the previous years. With the exception of a poor sandy plot, these lands are very rich in nitrogen (containing nearly double the amount of nitrogen) when compared with the plots in experimental areas.

Laboratory experiments in nitrogen fixation by algae were continued during the year. The alterations introduced in the technique of carrying out the experiments, which have given concordant results in duplicate, have made it certain that algae do fix a certain amount of nitrogen by themselves alone, as any possibility of symbiotic action with bacteria was prevented in the experiments. Perhaps algae contribute a large share of the rise in nitrogen content in soils observed towards June or July *i.e.*, after the break of monsoon.

Nitrification. Further experiments on nitrification in continuation of the last year's work were carried out to find in what form and

under what conditions loss of nitrogen takes place when large amounts of nitrogen get concentrated in the soil as organic or ammoniacal or nitrite nitrogen as a result of spreading the manure in a field. In these circumstances, if the nitrifying flora is not active in the soil, the chief loss that takes place is due to volatilization of ammonia when the temperature ranges somewhere between 28°C.—34°C., as is the case here in the hot season and at times in the rainy season. Very little nitrogen is lost at temperatures lower than 23°C. Hence there is no danger of any loss occurring through this cause in the cold weather.

Effect of sulphur and sulphur compounds on nitrification. Sulphur, sodium sulphite and sodium thiosulphate were found to lower the rate of nitrate accumulation in the soil if added along with cake or ammonium sulphate. Generally, the effect lasts for about two weeks in the case of sulphur and sodium thiosulphate, when these substances are applied at a concentration of 0·1 per cent. and 0·25 per cent. (on sulphur basis). The effect, however, practically completely disappears after this period. This effect is probably due to the reduction of nitrates to the stage of ammonia, as practically the whole amount of the nitrogen is recovered in the form of nitrates progressively after this period of two weeks. That this is the case is further seen by adding these substances to a soil already containing nitrates when a reduction in nitrate nitrogen is observed for the first two weeks after which the nitrogen reappears as nitrate.

In the case of sodium sulphite, however, although the inhibitory effect disappears at the end of two weeks when the concentration is 0·1 per cent. of the soil (on the sulphur basis), the effect persists when the concentration is 0·25 per cent. for over a period of 16 weeks. This behaviour of sodium sulphite will be further investigated. This investigation was necessitated by the fact that sulphur is being used in the process recommended for bone and phosphate solubilisation and these compounds of sulphur are likely to be produced during the fermentation of sulphur.

Two soils from Netarhat farm were tested for their nitrifying power with lime, with superphosphate and with lime and superphosphate together. Mustard cake at the rate of 30 mg. nitrogen per 100 gms. soil was used as the substance to be nitrified. It was found that superphosphate stimulated the process of nitrification to a slight extent in one of the soils, while it depressed in the other. Addition of 1 per cent. lime gave an enormous increase of nitrate nitrogen over the control in one soil *viz.*, 21·6 mgm. nitrate nitrogen per 100 gm. soil as against 3·9 mgm. in eight weeks, representing a gain of 450 per cent. over the control. The figures for the other soil were 18·0 mgm. in control without lime and 26·4 mgm. with lime representing a gain of 50 per cent. over the control.

Nitrification of calcium cyanamide. The work on the nitrification of calcium cyanamide was continued. Further results, in addition to, or modifying, those quoted in the report for 1926-27 are as follows:—

(*a*) *Cawnpore and Kalianpur soils.* No nitrification of cyanamide nitrogen added at the rate of 30 mgm. nitrogen per 100 gm. soil in twenty-nine weeks.

(*b*) *Black cotton soil.* Nitrogen added at the rate of 5 mgm. per 100 gm. soil. No nitrification in seven weeks, but 2·1 mgm. nitrified in three months, 4·2 mg. in 5 months and complete nitrification in six months.

(*c*) *Ranchi soils.* Nitrogen added at the rate of 30 mgm. per 100 gm. soil.

Upland soil. No nitrification of cyanamide in twenty-eight weeks, but 24 per cent. had nitrified by the thirtieth week. Nitrification of sulphate of ammonia was slow, only 22 per cent. had nitrified in twenty-four weeks. Nitrification of cake was better. Thirty per cent. had nitrified in six weeks, and the maximum nitrification, 52 per cent., was found after eighteen weeks.

Valley soil. Nitrification of cyanamide started by the sixteenth week and 58 per cent. nitrified by the twenty-ninth week. Nitrification of sulphate of ammonia and of a cake started after the first week; 72 per cent. of the sulphate of ammonia and 64 per cent. of the cake had nitrified by the sixteenth week.

Intermediate soil. Nitrification of cyanamide started about the eighteenth week, and percentages nitrified were ten in twenty weeks, thirty-two in twenty-eight and sixty in thirty-two weeks.

Nitrification of ammonium sulphate and of cake started by the fourth week. That of ammonium sulphate was slow, only 30 per cent. was nitrified in fourteen weeks, 39 per cent. in twenty-four weeks and 52 per cent. in thirty-two weeks. Of the cake, 35 per cent. nitrified in six and 65 per cent. in fourteen weeks.

(*d*) *Karimganj soil.* In the first set of experiments there was no nitrification of ammonium sulphate or of cake in thirty-two weeks, but nitrification of cyanamide started at some time after the sixth week, and by the eleventh week 32 per cent. of the added nitrogen was nitrified, and the maximum, sixty-seven per cent, after the twenty-fourth week. This was repeated, and gave a similar result, except that nitrification of the cake had begun by the seventeenth week,

but only about 5 per cent. of its nitrogen was recovered as nitrate in twenty-seven weeks.

As this soil had an acid reaction, pH=5·8, 1 per cent. of lime was added. Nitrification of the added ammonium sulphate, cake, and the original soil nitrogen had started by the fourth week and proceeded rapidly. The recoveries of nitrate by the eighth week were 33·6 mgm. from ammonium sulphate, 28·8 mgm. from cake, and 12 mgm. from the control (soil and lime). The addition of the 30 mgm. dose of cyanamide had depressed nitrification to such an extent that only 5 mgm. nitrate nitrogen were recovered after the eighth week.

With a smaller dose of cyanamide, supplying 5 mgm. nitrogen per 100 gm. soil, slightly less nitrate than from the control was recovered up to the sixth week, but at the eighth the amounts were 15·6 mgm. and 12 mgm., a recovery as nitrate of 3·6 mgm. of the added 5 mgm. of nitrogen. Such large quantities of nitrate were found in this soil by the mere addition of lime that no nitrogenous manures need be applied to it for the present.

Two new manures. Samples of Diammonphos and Nitrophoska were received for experimental purposes in this section. They were found to nitrify as rapidly as ammonium sulphate in Pusa soil; and on grass plots had effects similar to that of ammonium sulphate *plus* superphosphate, which was found to have the best effect. On mustard grown in pots the effect of Diammonphos was equal to that of ammonium sulphate *plus* superphosphate.

Mahua refuse. A sample of spent *mahua* flowers after distillation, the *mahua* refuse of the distillery, was received from Ranchi to test its manurial value. The sample contained about 2 per cent. organic nitrogen and 0·05 per cent. nitrate nitrogen. Nitrification experiments conducted with this material showed it to be nitrifying more slowly than farmyard manure with which it was compared in Pusa soil.

Artificial farmyard manure. Three samples of artificial farmyard manure were brought from Dacca Farm where they were prepared by the Bengal Department of Agriculture and tested for their ability to be converted into nitrates. They were found to nitrify more slowly than the local farmyard manure with which a comparison was made. Among themselves, "The Adco treated" appeared to be very slightly better than the "Bonemeal *plus* Ammonium sulphate treated" which was better than "the Refuse treated with water."

Carbon dioxide respiration in soils. Respiration experiments with mustard cake and *mahua* cake were carried out. As *mahua* cake contains only 2 per cent. of nitrogen compared with 6 per cent. in mustard cake, two lots of soil were given *mahua* cake, and to one of these was added nitrate of soda to bring up the amount of added nitrogen to that

in the soil to which mustard cake was added. Half a gram of cake was added per 100 gm. soil.

At the end of 15 days the amounts of carbon dioxide given off were 426 mgm. from the soil with mustard cake, 279 mgm. from the soil with *mahua* cake alone and 312 mgm. from the soil with *mahua* cake and nitrate. The addition of nitrate, therefore, stimulated the breaking down of the *mahua* cake, but even so the *mahua* cake was much more refractory than mustard cake.

Biological analysis of soils. A number of biological analysis of soils was undertaken. The object in view was different in each case.

To compare the manurial value of two organic manures like farmyard manure and green manure both of which supply about the same kinds of plant foods but probably in different proportions, farmyard manure and fermented green manure were added to the soil in quantities equal to those usually applied to the field, *viz.*, 5 tons and 10 tons per acre respectively. Nitrification, carbon dioxide production and yield of crops grown in pots were tested. Very little difference could be seen between these treatments showing that they are about equal in value at the rates at which they were supplied.

While this experiment shows that the treatments are practically of the same value in the first year of their application, in order to see how far this holds good where the treatment is continued for some years as in the permanent experiments in the Punjab field, samples from five plots were collected from this area, *viz.*, plot No. 3 treated with farmyard manure, No. 10 complete minerals, No. 11 no manure or legume, No. 12 green manure, No. 16 green manure and superphosphate. The samples were compared for their (1) Nitrogen content, (2) Nitrification with oil cake, (3) Carbon dioxide production with and without the addition of oil cake, and (4) Cellulose destroying power.

The plots could be arranged as regards their cellulose destroying power in the following order: 16 > 10 > 3 > 12 > 11. Their nitrogen contents were in the same order 16 > 3 >12 >11 (that of No. 10 was not determined). There was very little difference in the decomposition of added oil-cake both as regards nitrate formation and carbon dioxide production, showing that there is not as yet any change in the number and kind of bacteria necessary to decompose an added manure like oil-cake in spite of the fact that there is variation in their nitrogen content of over 50 per cent. This examination will be continued.

Biological analysis of three samples of soil from a sugar estate at Sahmaw, Burma, was carried out. It was found that liming of the soils stimulated nitrification to a large degree. In six weeks the nitrate was increased from 38 to 53 per cent. of the added nitrogen in one soil and from 26 to 51 per cent. in another. Extract of the worse of the two

soils totally inhibited growth of *B. prodigiosus*, showing that the poor yielding capacity of this soil is due to some inhibitory factor.

Physico-chemical properties of soil as affecting bacterial growth. Samples of (1) natural acid soil, (2) the same soil treated with acid and (3 and 4) the acid treated soil to which different amounts of lime were added, were received from the Physical Chemist for bacteriological analysis. The object was to find out in which sample the ammonifying, nitrifying and nitrogen-fixing bacteria thrive. The preliminary experiments soon showed that the natural acid soil contained the ammonifying, nitrate-forming and nitrogen-fixing organisms and is capable of supporting them. The acid treated soil with active H. ions probably on account of its treatment does not contain any of these organisms and the altered conditions produced by the treatment does not support the organisms even if introduced. The neutralized samples do not contain the original organisms but are capable of supporting them if the organisms are inoculated into them.

In connection with the growth of bacteria in the soil extract of these four samples, it was observed that extracts of the partially neutralised soil and completely neutralized soil contained colloidal matter in suspension even after centrifugalization, while that of the acid soil was clear. *B. Prodigiosus*, when inoculated in these extracts, gave better growth in the colloidal extracts than in the clear extracts of the acid soils.

This interesting observation has led to the study of the important question whether plants and bacteria can make use of the food material that is in the absorbed state in soils. In collaboration with the Physical Chemist, this problem is being studied by observations on the growth of some plants as well as some soil organisms in soil suspensions containing nutrient material only in the absorbed state. The results, so far obtained, show that plants and bacteria can make use of the food material which is in the absorbed state.

In the course of these experiments observations were also made as to whether the toxicity of acid soils is due to the direct action of H. ions on bacteria and plants and it was found that bacteria and plants are affected detrimentally by the direct action of H. ions in the acid soils. Further work on the subject is in progress.

Another important line of work undertaken was to find out the relation of bacterial activity to the lime requirements of acid soils. It is well known that certain bacteria, *e.g.*, " Azotobacter sp." and " Nitrifying organisms " do not thrive in acid soils. Based on this fact, methods have been suggested to find the lime requirements of soils by observing the optimum growth of such bacteria in acid soils neutralized by different

amounts of lime. In using these methods, however, one is not certain about the exact relationship which the soil reaction bears to growth and activity of the different kinds of soil organisms. The several kinds of bacteria, used in these studies, can grow and thrive within a wide range of acidity, and no relation has as yet been definitely worked out between the growth or activity of any organism out of the different kinds used in such tests, and the soil reaction. It was of interest to find out, therefore, if the optimum bacterial activity of different kinds of organisms was in any way related to the various stages of reaction between lime and acid soils worked out by the Physical Chemist. The results so far obtained with one of the natural acid soils, indicate that the nitrifying bacteria with ammonium sulphate as the substance to be nitrified begin to be active just when the soil acidity is neutralized up to the stage called by the Physical Chemist as H_1 ; but at this stage the action of the organisms cannot proceed further in the absence of any base to neutralize the nitric acid formed by the organisms. If the nitrifying process is to run its normal course in the neutralized soil, it is necessary, therefore, that sufficient lime should be present over and above this stage H_1 to neutralise the nitric and the sulphuric acid produced, as a result of the activity of the nitrifying organisms, from the ammonium sulphate supplied. Further work on other natural acid soils is in progress to see whether this result holds good for acid soils in general.

Manuring trials with organic manures. In continuation of the experiments of the last year, *mahua* cake-charcoal compost was applied to see its effect on wheat in small plots. The plots were 18 ft. × 5ft. and the yields were obtained as given in the table below :

—	Per cent. increase in dry matter over control	Yield of dry matter	Yield in grain
		lb. oz.	lb. oz.
Control	..	6 2	3 6
Mahua cake	16·3	7 2	4 2
Mahua cake + soil fermented . .	22·4	7 8	4 2
Mahua cake + soil + charcoal fermented.	25·5	7 11	4 2
Mahua cake + charcoal fermented .	38·8	8 8	4 10

These figures indicate that the addition of charcoal to the *mahua* cake composts decidedly increases their manurial value.

Green manure. Experiments on the application of green manure (*Crotalaria juncea*) on different dates with and without previous fermentation were carried. The green manure was applied on the basis of its nitrogen content so that all plots received the same amount of nitrogen in the form of green manure. In case of fermented green manures, the periods for which it was fermented was one, two and three months, but the one month period was found to be optimum. Oats were sown as *rabi* crop on November 1, 1927.

The yield of oats is given in the following table :

Treatment	Grain		Straw	
	Md.	Sr.	Md.	Sr.
Green manure cut and applied 1st August . .	17	24	33	28
Green manure cut 1st August, applied 1st September after fermentation.	30	20	44	10
Green manure cut and applied 1st September .	17	5	32	14
Green manure cut 1st September, applied after 1 month's fermentation 1st October.	23	10	38	22
Green manure cut and applied 1st October . .	24	10	31	35
Green manure cut 1st October, applied 1st November.	23	12	31	35

Comparing these figures, we find that fermented green manure is better in the first two cases ; probably the application on 1st November just at the time of sowing oats had a bad effect on the germinating power of oats and on the crop. Late application of green manure on 1st October seems to have a good effect, probably because the nitrates and other soluble plant food are not washed out of the soil as has been previously observed to be the case.

Phosphate solubilisation. Composts prepared from bonemeal, sulphur, sand and charcoal in this laboratory were supplied in sufficient quantities to each of the experimental stations, Aligarh in U. P., Neterhat in Bihar, and Karimganj and Shillong in Assam for field experiments. The compost was compared with bonemeal and superphosphate at the above stations. Similar experiments were conducted in the experimental area of this section. The experiments differed at the different stations as regards the basal dressing of manure, but the main result that emerges from the results received so far is that the compost has given higher yields than superphosphate. The increase in yield given by the superphosphate and the compost is given in the following table.

Increase in yield of potatoes over the control plots.

	Maunds per acre		Bonemeal
	Compost	Superphosphate	
Pusa	26	20	11
Aligarh	31	17	—23
Neterhat	29	10	17

The results at the Karimganj station were vitiated by the attack of cutworms.

Other crops tried in the experimental area of this section were onions and wheat, both of which gave better yields with compost than with superphosphate.

Not only is the immediate effect of compost on the crop to which it is applied superior, but it has a residual effect better than that of superphosphate. The residual effect of bonemeal is, however, greater than either of these manures; but the total yield of the three successive crops taken after the application of these manures is greater with the compost than superphosphate, which is again better than bonemeal.

A depressing effect of bonemeal on the yield of potatoes is already noted in the above table at Aligarh farm (—23). A similar depressing effect has been observed at Pusa and Neterhat in the case of bonemeal in the absence of any basal dressing of other manure. It is not possible to say why bonemeal, although it may not be easily available to the crop, should give actually a lower yield than the control. Further investigation on this point will receive attention in future.

IV. Silage.

Further investigations on silage were carried out on similar lines to those of the last year. In two sets of experiments, one batch of silage was kept at 30°C. and another at 40° C. Bacterial counts were lower and development of acidity was slower in the batches held at 40°C. than in those held at 30°C.

Comparison of the bacterial counts and acidity of maize and *juar* silage shewed that in *juar* silage acidity according to determination of total acidity and pH. did not develop so rapidly or to so high a degree as in maize silage. The counts shewed that the numbers of bacteria in *juar* silage were lower than in the maize silage in the early stages, but they did not diminish so rapidly with age.

Plates made from the juice of silage one day old gave almost a pure culture of raised, slimy glistening colony of an organism that appeared from its cultural characters to be *Achromobacter fermentationis* (Chester).

Occasionally acid forming colonies were found on plates poured from material one day old, and on purple lactose agar the colonies obtained from material three to eight days old were nearly all acid formers, of the type *Streptococcus lacticus*, the common organism of sour milk. A few lactobacilli were sometimes found.

It was noticed that the silage made early in the monsoon, when the maize contained a high percentage of moisture, did not develop acidity so rapidly as that made from maize of a later growth. When there was a good development of acidity in the first five days (over two per cent), a very good silage resulted. In *juar* silage the acidity was slower in developing than in the maize silage, and it was observed that it was far more liable to have a putrefactive odour. The acid produced in the former appeared to be insufficient to check the activity of putrefactive bacteria in the early stages of the process.

V. Fermentation Studies.

A study was made of the conditions necessary for the successful manufacture of *shirka*, vinegar from cane juice, *gur*, molasses, etc. The present methods of the Indian manufacturer depend upon exposing the cane juice, palm juice or a solution of *gur* to natural infection of airborne yeasts and vinegar bacteria. The final product "shirka" obtained under these conditions is not always of uniform quality and is low in its acid content. A technique has been worked out which gives a final product with a concentration of 6 to 7 per cent. acetic acid. The conditions found necessary were (1) the action of the yeasts should be followed by that of vinegar bacteria; (2) the latter organisms work best in flat layers. The particular organism used in the laboratory was *Bacillus aceti* (Hansen) which gave a concentration of 7 per cent. acetic acid in 4 days at 30°C.

VI. Dairy Bacteriology.

Bacteriological examinations of the milk supplied by the Pusa farm were carried out during the year. The following table gives the average plate counts in each month of the year together with the *B. coli* organisms in the samples.

Month	Average count per c.c. of milk	*B. coli* in $\frac{1}{10}$ c.c. Number of days present	*B. coli* in $\frac{1}{100}$ c.c. Number of days present
July, 1927	19,300	9 out of 12	4 out of 12
August, 1927	27,800	All	7 out of 16
September, 1927	33,300	All	9 out of 12

Month	Average count per c.c. of milk	*B. coli* in $\frac{1}{10}$c.c. Number of days present	*B. coli* in $\frac{1}{100}$c.c. Number of days present
October, 1927	13,700	3 out of 10	*Nil.*
November, 1927	12,000	7 out of 15	2 out of 15
December, 1927	9,300	3 out of 10	*Nil.*
January, 1928	6,100	1 out of 14	*Nil.*
February, 1928	3,800	5 out of 13	*Nil.*
March, 1928	4,400	All	8 out of 12
April, 1928	12,700	All	9 out of 12
May, 1928	14,900	All	4 out of 14
June, 1928	15,400	All	3 out of 12

The figures show a progressive rise of plate counts during July, August and September, 1927, the highest figure being reached in the last mentioned month. After this there is a gradual decline up to February, 1928 which records the lowest figure. From March, 1928 there is a gradual rise again. An attempt to correlate these figures with humidity or maximum daily temperature or the temperature in the laboratory fails, as no definite relation could be traced. Unfortunately, no observations were made of the temperature at the time of taking the sample from the dairy. The effect of the seasons is, however, well brought out in the above table. Whether the difference in food consumed by the animals in different seasons has a bearing on the variation in bacterial counts of milk is a point which requires some investigation.

It has been observed in laboratory experiments that the use of covered pails tends to lower the plate counts markedly, especially when the temperature is comparatively low. This is more or less confirmed by the fact that the lowest average counts are recovered in the months of January, February and March of 1928, as compared with those of the same months in the previous three years. In the summer season, however, the same marked lowering was not observed. Large numbers of *B. coli* organisms were also found in the months of April and May. The counts came to their normal figure in June, as compared with those of previous years.

Use was made of the "Frigidaire" as a cold incubator to test the keeping qualities of milk at 48°—50°F. Samples of milk were kept every week to see how long they would be fit for consumption, by plating, heating, and alcohol test and it has been found that more or less the keeping quality of milk is affected by the number of bacteria originally

present in the milk, the less the number of bacteria, the better the keeping quality. Generally, it has been found that the milk kept in the "Frigidaire" is good for 6 to 9 days in November, December, January, February and March. But from April to September it keeps good for 4 to 6 days only, showing a distinct seasonal effect like the plate counts. In order to see how far the bacterial plate count of the mixed milk agrees with number of bacteria present in individual cows, an attempt was made to find out the number of bacteria present in the milk of cows taken during the middle of milking operation so as to exclude those associated with the first milk drawn. Milk from individual cows selected at random was tested from day to day. Sometimes, but not always, the first drawn milk from those cows was also taken for comparison. In each case the milk was collected directly in sterile bottles. It has been found from these experiments that the bacterial content of milk of different cows varies to a great extent; the milk of the same individual cow also varies from day to day depending probably on the food consumed by her and also perhaps due to the difference in temperature of the days. Certain cows have so far consistently given a very low number of bacteria (200—1000 per c.c.) in their middle milk.

The first portion of the milk taken for comparison generally showed 5 to 6 times the number of bacteria present in the middle milk, showing a sort of relationship with the numbers present in the middle milk.

Milk-fermenting yeast. A yeast isolated from a sample of spoilt milk from the Karnal dairy was found to ferment the lactose of milk into alcohol and carbon dioxide. The cultural and other characteristics of this organism were studied and showed it to be a torula. It does not form *Ascospores*, ferments many sugars but not maltose, and produces about 2 gm. alcohol per 100 c.c. milk in 5 days' time at 30°C. This torula might prove, therefore, of some economical importance for conversion into alcohol of whey (*chhana* water), which at present is a waste product after the separation of casein in the preparation of sweet-meats in Bengal. The organism is similar to *Torula lactis* (Adametz) Heinz and Cohn, but differs from it in the size of cells and its thermal death point which is 66°C. in the case of torula investigated in this laboratory and 56°C. in the case of *Torula lactis*.

VII. Plant diseases.

Potato rot. Two samples of rotting potato tubers were received from the Punjab. In both samples the original injury seemed to be caused by a *Fusarium* after which the bacterial rot set in.

Potato ring disease. Samples of potatoes suffering from ring disease were received from the Bihar Government farm at Netarhat. The microtome sections of the tissue showed bacteria in the cells, but among the cultures made from the tissue there was none of *B. Solanacearum*.

Tobacco plants inoculated from these cultures did not take infection owing probably to the lateness of the season.

Tobacco leaf spot. Specimens of tobacco attacked by leaf spots were received from Dharwar farm and organisms isolated from these appeared to answer the description of the causative organism of Wisconsin leaf spot of tobacco. Inoculation experiments did not prove successful probably due to lateness of the season. These experiments will be repeated next September.

Sugarcane Mosaic. With a view to find out whether there is anything in the view put forward by some investigators that the mosaic is caused by protozoa, microtome sections were cut of the healthy and diseased cane leaves. A study of the slides does not reveal any difference in the micro-structure of the diseased and healthy tissues. There were large numbers of cell nuclei of different shapes in the diseased tissue, likely to give a wrong impression that they are flagellate protozoa. From a detailed comparative examination of the diseased as well as healthy tissue in sections, it can be concluded that the so-called " flagellates " of certain observers are nothing but cell nuclei.

VIII. Storage experiments.

Cold storage of mangoes. Raw, half ripe and ripe mangoes were kept at a temperature of 48°—50°F. for different periods in order to see how far the ripening enzyme is affected by the low temperature. The raw and half ripe mangoes were removed at intervals and kept at the laboratory temperatures to see whether they ripen normally. It has thus been ascertained that the raw and half ripe mangoes could be kept for a fortnight at this low temperature, then ripen normally at the laboratory temperature of 88°F. Continuous storage at the low temperature delays the ripening of half ripe mangoes by about one month.

The ripe mangoes preserve their appearance and taste for about three weeks after which period they lose the appearance but still retain their taste for another week. They are thus prevented from rotting, which takes place very rapidly at the higher temperatures tried, *viz.*, 75°F. and 88°F. After full ripening, death of the cells of outer skins takes place and saprophytic fungi and bacteria gain entrance through these. The preservation of mangoes at 50°F. for about a month means that good varieties of mangoes could be transported long distances and exported out of India provided refrigerating cars are available. The temperature to be maintained in these cars need not be lower than 48°—50°F.

Investigations on the organisms concerned in the spoilage of mango and other pickles and ripe mango juice were carried out and some information gained as to the concentration of different spices necessary to

prevent spoilage. Of the usual spices used, salt in a concentration of 10 per cent. and cloves in a concentration of 1 per cent. have good preservative action. Of the other spices, none by themselves could prevent fungal attacks. In combination with salt or heating to 100°, they showed some preservative action.

In the case of ripe mango juice, cinnamic aldehyde and eugenol were tried with and without heating the juice to 100°C. in the steam sterilizer. With non-heated juice, a concentration of 1 in 2,000 of cinnamic aldehyde and 1 in 500 of eugenol was necessary to prevent growth of spoilage organisms; while if the juice is heated to 100°C., a concentration of 1 in 4,000 of the former and 1 in 1,000 of the latter was sufficient for the same purpose.

Some organisms, yeasts, bacteria and fungi, causing spoilage of mango juice and mango pickles were isolated in pure cultures and were found to be completely inhibited at a concentration of 1 in 4,000 of cinnamic aldehyde in culture media; whereas a concentration of 1 in 2,000 was found necessary to accomplish the same purpose when eugenol was used.

Onion storage. The crop of onions in the experimental area of this section was stored in order to see the losses due to rotting and driage. Seven maunds were spread out on rack and 47½ seers kept in small baskets. The onions were examined at intervals of ten days to remove the rotten ones and weight again taken in the middle of November when most of the onions were sprouting.

The onions spread on the racks suffered a loss of 58 per cent. and those in the baskets 46 per cent. The weights of rotten onions were 5·5 per cent. of the initial in the case of the former and 13·1 per cent. in the case of the latter.

A greater part of the loss is thus seen to be due to driage.

IX. Electrolytic Chlorogen.

The apparatus belonging to the Bihar and Orissa Government was taken over by the Medical Department and transferred to Laheria Sarai in December, 1927. E. C. was manufactured by the locally made cells for the usual Estate supplies and the Sadar Hospital, Muzaffarpur.

X. Programme of work for 1928-29.

Work will be done on the following subjects:—

1. Soil nitrogen.
2. Bacteriological analysis of acid soils.
3. Nitrification in acid soils.

4. Bacteriology of silage.
5. Fermentation of straw and artificial farmyard manure.
6. Dairy bacteriology.
7. Plant diseases.

XI. Publications.

Joshi, N. V.. . .	Note on "The Tolerance of Nitrifying Organisms to high Concentrations of Ammonia in Soil." (*Agri. Jour. India*, Vol. XXIII, Part I, January 1928.)
Vyas, N. D. . .	A method of increasing the manurial value of *Mahua* cake. (*Agri. Res. Inst. Pusa Bull.* No. 176.)
Ram Ayyar, C. S. .	Micro-organisms and the production of *Dahi*. (*Agri. Jour. India*, Vol. XXIII, Part II, March 1928.)
Joshi, N. V.. . .	An economical method of manuring with Sann-hemp. (*Agri. Jour. India*, Vol. XXIII, Part II, March 1928.)
Walton, J. H. . .	Note on "The Loss of Weight of Onions on Storage at Pusa." (*Agri. Jour. India*, Vol. XXIII, Part II, March 1928.)

REPORT OF THE IMPERIAL MYCOLOGIST.

(W. McRae, M.A., D.Sc., F.L.S.)

I. Charge and Establishment.

Dr. McRae held charge of the Section throughout the year. The post of Second Imperial Mycologist was still held in abeyance. Mr. M. Mitra, First Assistant, went on leave to England for one year and nine months from the 5th September, 1927, for further study. Mr. L. S. Subramaniam, F.L.S. was appointed to act for him, two Fieldmen were promoted to act in the two Assistants' leave vacancies and two temporary men were recruited for the two Fieldmen's vacancies.

II. Training.

Mr. Abdus Sattar, B.Sc., who was sent by the Punjab Government, finished his post-graduate course of training on the 23rd August, 1927. Ten students from the Imperial Institute of Animal Husbandry and Dairying, Bangalore, received short courses in the diseases affecting cereal and fodder crops. Dr. K. D. Bagchee, Forest Mycologist, Dehra Dun, worked in the herbarium and library for a short time in connection with his study of pine rusts.

III. Diseases of Plants.

(1) *Wilt of rahar* (*Fusarium vasinfectum* Atkinson on *Cajanus indicus*). At one end of each of the plots in the three pairs laid down last year to test the velocity of spread of wilt in land manured with superphosphate and land given no superphosphate, infective material was placed. It consisted of pieces about three inches long of the lower parts of stems that had wilted in the previous season. One piece was buried in the furrow between a group of four plants in the two adjacent ridges and three such rows of infective material were laid out. The plants were spaced three feet by three. Infection became well established in each plot and in two plots a small stray group occurred outside the range of infection from the end. The number of plants in each plot was—

Superphosphate	102	77	102
No superphosphate	81	68	57

The experiment will be continued for about three years when from previous experience the infection may be expected to have reached the far end of the plots. No more has occurred than the establishment of wilt at one end of each of the previously wilt-free plots and this may be due to the fact that this is the year of lowest wilt during the nine years that accurate counts have been kept in Pusa.

The number of wilted plants in each of the plots of the permanent manurial series is as follows.

Wilted rahar plants on the Permanent Manurial Plots at Pusa, B series.

Plot	Manures supplied per acre	No. of wilted plants	Percentage
I	No manure	22	0·9
II	Farmyard manure to supply 10 lb. nitrogen per acre.	72	2·5
III	Farmyard manure to supply 20 lb. nitrogen .	340	12·0
IV	Farmyard manure to supply 30 lb. nitrogen .	807	31·6
V	Rape cake to supply 20 lb. nitrogen . .	133	5·0
VI	Sulphate of ammonia to supply 20 lb. nitrogen	142	5·0
VII	Sulphate of potash to supply K_2O as in No. III	110	4·0
VIII	Superphosphate to supply P_2O_5 as in No. III .	483	18·0
IX	Sulphate of potash to supply K_2O as in No. III Superphosphate to supply P_2O_5 as in No. III .	350	14·0
X	Sulphate of ammonia to supply nitrogen . . Sulphate of potash to supply K_2O as in No. III Superphosphate to supply P_2O_5 as in No. III .	240	10·4
XIII	Deep-rooted leguminous crop (*rahar*) in a cereal rotation.	48	2·0
XIV	One deep-rooted (*rahar*) and one shallow-rooted (peas) leguminous crop in the rotation.	113	5·0
XV	A leguminous crop and green-manure in the rotation.	64	3·0
XVI	Green-manure and superphosphate to supply P_2O_5 as in No. III.	670	33·8

The incidence of the disease is in general conformity with that of previous seasons except that plot No. XVI has a very high number of wilted plants as it had in the previous season, 1925-26, when *rahar*

was grown in the B series. Formerly and consistently so in the A series the number of wilted plants in plot No. XVI was intermediate between the numbers in the superphosphate plots and those in the no-superphosphate plots, but in the last two seasons in this series it is much higher than the highest of those in the superphosphate plots. The average of the three superphosphate plots (VIII, IX and X) is 14 per cent., of the five no-phosphate plots (I, XIII, XIV, VI and VII) is 3·4, while that of No. XVI is 33·8. The record of wilt in these manurial plots have led to the conclusion that superphosphate favours the disease, that green manure is unfavourable to it and that both together have an effect intermediate between the two. The record of the green-manure and superphosphate plot for the last two seasons in B series suggests that some other factor has had a more dominant influence in favour of the wilt.

Owing to the configuration of the land, this plot is temporarily flooded during heavy rains till the surplus water has run off the whole series of plots. This probably induces a temporary water-logged condition that is adverse to the growth of *rahar* which is well known not to be able to withstand flooding during the monsoon and that renders the plant more liable to the attack of wilt.

The investigation which has for its object the isolation of a type of *rahar* which will prove resistant to wilt disease was continued in collaboration with the Imperial Economic Botanist. The progress of the work is satisfactory and we hope that next year the work, one stage of which will be concluded then, will be written up in detail.

(2) *Mosaic disease of sugarcane.* Secondary symptoms of mosaic were noted for the first time in India by the Government Mycologist, Coimbatore, on the stems of Red Mauritius and Java Hebbal and shown to me while I was there on a visit. They consist of loss of colour in long blotches, death of the tissue immediately below the blotch, shrinking of the blotched area, shrinking of the diameter of the cane and stunting. Such symptoms, however, have not been seen in canes in Northern India.

(*i*) *Distribution.* In addition to the localities and varieties in the two last reports, the following canes have been observed to have mosaic disease :—

Bihar. Pusa—Co. 223, Co. 273, Co. 294, Co. 295, Co. 296, Co. 298, Co. 299, Co. 300, Co. 303.

United Provinces[1]—

Gorakhpur—Co. 213.

Raya—Co. 213.

[1] Reported by the Plant Pathologist, United Provinces.

Madras[1]—

Presidency—Striped Mauritius, Ashy Mauritius, Q 116, Q 813, B 6450, B 6308, D 131, Bontha

Thick Cane Breeding Station. Co. 17, B 254, B 3412, H 109, P. O. J. 100, P. O. J. 920, P. O. J. 2696, P 67, Mauritius 33, S. H. 22, Bontha, Vellai, Green sport, Cheribon Brisbane, Pattapatti, Striped Cheribon, Batjan and one cross.

Cane Breeding Station. 2034 one clump.

Bombay—

Manjri—B 208, B 1528, B 6308, H. M. 165, H. M. 310 A, H. M. 310 B, H. M. 312, H. M. 315, H 109, J 139, P. O. J. 2727, Cavangerie, Purple Mauritius, Striped local, Black Tanna, Java, Waxy Red and five varieties with Indian locality names.

Amalsad—Co. 213, Striped Mauritius, White Mauritius, Khajuria and Malabari.

(*ii*) *Amount of disease.* (*a*) The amount of mosaic disease on the different varieties of thin canes varies considerably and the variation is well shown in Table 1 which is a record of the disease on the canes grown *on a field scale* at Pusa. Though, as is usual with most diseases in the field, the diseased plants were scattered irregularly throughout the area occupied by any one variety still, considering the position of the varieties on the farm, it is a reasonable assumption to make that they had an approximately equal chance of becoming infected, hence the figures recorded may be taken as a fairly correct evaluation of the relative susceptibility of the varieties in this environment. Co. 232 is highly susceptible and has been discarded. Co. 205 is also very susceptible, Co. 250, Co. 287 and Co. 213 are fairly susceptible, Co. 210, Co. 273, Co. 275, Co. 281, Co. 282, Co. 286, and Co. 288 are resistant, while Co. 214, Co. 248, Co. 270, Co. 280 and Co. 290 are highly resistant. The last four canes were grown in the farm only, while about 1,000 acres of the first (Co. 214) were grown in the surrounding districts in 1927-28 but no mosaic mottling has ever been seen though this cane has been examined carefully on a large scale.

The table also records the results of roguing for two seasons and shows that in every case the amount of disease has been substantially reduced to below 0·5 per cent. except in Co. 205. The reduction of the disease will likely be more difficult in this variety than in the others, because the symptoms show up rather later and become less conspicuous as the season advances.

[1] Reported by the Government Mycologist, Madras.

TABLE 1.

Mosaic on sugarcane at Pusa.

	Percentage of mosaic stools				Area
	1925-26	1926-27	1927-28		1927-28
			June.	October.	Acres.
Co. 205 . .	+	60	4·2	1·2	5·71
Co. 210 . .	2 to 5	·01	·01	0	6·44
Co. 213 . .	5 to 10	1·2	·5 ·4	·02	2·60 12·18
Co. 214 . .	0	0	0	0	·45
Co. 232 . .	90	..	..	..	..
Co. 248 . .	0	0	0	0	·21
Co. 250 . .	20	..	..	..	..
Co. 270 . .	·00 (2 clumps)	0	0	0	·60
Co. 273 . .	·00	·01	·02	0	2·05
Co. 275 . .	1	0	·03	0	2·02
Co. 280 . .	0	0	0	0	·99
Co. 281 . .	3	+	·2	·16	·13
Co. 282 . .	3·6	+	2·6	·45	·07
Co. 286 . .	1·7	..	..	..	..
Co. 287 . .	15	+	1·1	·17	·60
Co. 288 . .	00	+	..	..	..
Co. 290 . .	0	0	·008	0	1·70

The sign .. indicates that the variety is no longer grown at Pusa. The sign + indicates the presence of mosaic though the percentage was not determined.

(*b*) The following canes *in the nursery* at Pusa which were free from this disease last year were found to be infected in June 1927—

Co. 294 had 5 mosaic plants or 0·1 per cent.
Co. 295 had 3 mosaic plants or 0·1 per cent.
Co. 296 had 2 mosaic plants or 0·1 per cent.
Co. 298 had 1 mosaic plant or 0·2 per cent.

Co. 299 had 6 mosaic plants or 1·8 per cent.
Co. 300 had 3 mosaic plants or 1·6 per cent.
Co. 303 had 2 mosaic plants or 0·3 per cent.

In addition, Co. 223 had 8 mosaic plants or 5 per cent. It, however, was introduced to Pusa for the first time in 1927. Co. 297, Co. 301, Co. 302, Co. 304, Co. 306 and BH 10 (12) have shown no symptoms for two years, and thirteen seedling canes from Coimbatore as yet unnumbered, grown in the previous year in the Botanical Area, were free. Co. 307, Co. 308, P. O. J. 2714, P. O. J. 2725, P. O. J. 2696, P.O.J. 2727 were also free and this is the first season in which they have been grown in Pusa. Till the end of the season in February symptoms appeared on no other plant in the nursery. All of the infected canes except Co. 223 which was a new introduction were free from mosaic disease in Pusa in the previous year. The setts of Co. 223 were got from Lyallpur at the planting season. Subsequent examination in Lyallpur showed that the standing crop, whose sets had the same origin as those sent to Pusa, had 36 per cent. of infected clumps in July. It is thus likely that mosaic was introduced into the Nursery by this cane and then spread to the other varieties.

(*c*) With a view to estimate the amount of mosaic disease on the widely grown Coimbatore canes *in North Bihar*, cane-fields on seven estates scattered fairly regularly along a line of 120 miles were examined in July 1927. The record is given in Table II and the percentage indicated is that of mosaic clumps in the area examined.

TABLE II.

Place	Variety	Area acres	Percentage
Estate 1	Co. 213	6·0	0·8
	Co. 205	0·5	16·5
Estate 2	Co. 213	5·0	0
Estate 3	Co. 210	5·0	0·05
	Co. 205	3·0	16·0
Estate 4	Co. 213	13·0	0*
Estate 5	Co. 213	5·0	0·07
Estate 6	Co. 213	6·0	0·9
Estate 7	Co. 213	4·5	0·2
	Co. 205	1·7	10·0
	Co. 205	1·5	19·0

* Two clumps only were found.

Of 39·5 acres of Co. 213, examined in 6 localities 0·3 per cent. of the clumps were infected, of 6·7 acres of Co. 205 examined in 4 localities 15 per cent. and of 5 acres of Co. 210 examined in one locality 0·05 per cent. We believe that these figures indicate correctly the position in North Bihar with regard to those three canes. The percentage of mosaic disease in them is far less than in Hemja which they are gradually replacing.

(*d*) At Manjri Agricultural Station in Bombay Presidency three varieties of cane, Java 33A, Java 36 and Red Mauritius, were found to be infected with mosaic disease in November 1925, whereas twenty-two other varieties of medium and thick canes that were mostly grown in small plots had become infected by August 1927. Seven of these, *viz.*, B 208, B 1528, B 6308, Cavangerie, Striped local, Java and Waxy Red had scattered cases only, three *viz.* H. M. 310 A, H. M. 165 and P. O. J. 2727 had up to four per cent., four, *viz.*, H. 109, Purple Mauritius, H. M. 315 and H. M. 310 B had from 30 to 50 per cent. and eight were fully infected, *viz.*, H. M. 312, J 139, Black Tanna and the five varieties with Indian locality names. At Amalsad Agricultural Station, Striped Mauritius had scattered cases, Malabari one per cent., Co. 213 thirteen per cent., White Mauritius forty-two per cent. and Khajuria 75 to 100 per cent.

(*e*) At Gurdaspur Agricultural Station in the Punjab thirteen varieties were found to be infected in 1925 whereas in July 1927 fourteen other varieties of thin canes had become infected. Five of these had scattered cases, *viz.*, Co. 244, Co. 250, Co. 251, Co. 267 and Co. 276, while the rest had from one to three per cent. It is also interesting to note in certain of the varieties the difference in the amount of infection during the last two seasons in Gurdaspur. In most cases it varies from scattered cases in 1925 to three per cent. in 1927 but Co. 210 had scattered cases in 1925 and ten per cent. in 1927, while Co. 270 and S. 48 had scattered cases in 1925 but in 1927 both had 20 per cent. of infected clumps. At Lyallpur Agricultural Station the infection was heavier and reached a maximum of 36 per cent, in Co. 223.

(*f*) The Dairy Farm at Karnal in the South-east of the Punjab is the only agricultural station we have visited where mosaic disease was not found on cane. Here Co. 205, Co. 213, Co. 223, Co. 287 and Co. 290 are grown on about fourteen acres.

According to the information available, the amount of mosaic disease on the Coimbatore canes is small in North Bihar and comparatively small throughout northern India where a percentage above 15 is rare. In the tropical parts of India such as Lower Burma, however, the two Coimbatore canes tried, *viz.*, Co. 213 and Co. 210, are fully infected. The thick canes in tropical India and those in northern India, of which there are few, are much more heavily attacked by mosaic disease, percent-

ages up to 100 being not infrequent. There is general ground then to believe that on the whole the thin canes are resistant. It must not be forgotten, however, that the growing season in northern India is a short one and probably limits the period of activity of whatever insects carry the disease. This was definitely so in the season 1927-28 during which mosaic symptoms appeared on the leaves of naturally infected cane from May to September in Pusa while in Coimbatore they appeared from June to January.

(*iii*) *Spread.* The record of three plots whose setts were cut from cane clumps known to be free from mosaic disease gives a further idea of the amount of spread in Pusa by natural means. In plot No. 1 Co. 210, Co. 213, Co. 214, Co. 275, Co. 290 and Uba were grown *in alternate rows* with cane from mosaic setts of Co. 213, Co. 232, Co. 250, Co. 281, and Co. 287. Eight clumps of Co. 213 showed leaf-mottling in June and two more in July while two clumps of Co. 275 showed signs in June out of about 111 plants.

In plot No. 2 the small *adjacent* blocks of 22 cents of mosaic and non-mosaic Co. 213 and of 14 cents of mosaic and non-mosaic Co. 287 of the previous year were rattooned and the 15 plants in the non-mosaic Co. 213 and the 22 plants in the non-mosaic Co. 287 that became infected in the previous year were not removed. A further 1·2 per cent. of Co. 213 and 1·6 per cent. of Co. 287 became infected.

In plot 3 a block of 7 cents. of non-mosaic Co. 213 was grown *alongside* an equal area of mosaic Co. 213. 2·1 per cent. of the plants in the former block became infected. These results together with those of last year (which are given in the table for reference) show that during the two years mosaic disease spread by natural means to a small extent in Pusa. For cane grown in the field where infected clumps are scattered here and there no accurate records are available, but from the record of the roguing experiments it is likely that it was just under one per cent.

TABLE III.

Percentage of mosaic disease caused by natural spread.

Plot	Variety	Area	Percentage of 1926-27	Mosaic clumps 1927-28
1	Co. 210 .	1 line of 50-60 clumps in 1926-27	6	0
	Co. 213 .	and of 80 to 111 clumps in 1927-28.	..	9
	Co. 214 .	Ditto	0	0

Percentage of mosaic disease caused by natural spread—concld.

Plot	Variety	Area	Percentage of 1926-27	Mosaic clumps 1927-28
	Co. 275 .	1 line of 50-60 clumps in 1926-27 and of 80 to 111 clumps in 1927-28.	0	2·2
	Co. 290 .	Ditto	0	0
	Uba .	Ditto	0	0
2	Co. 287 .	14 cents	1·6	1·6 ratoon.
	Co. 213 .	22 „	0·5	1·2 „
3	Co. 213 .	7 cents	..	2·1
4	Co. 205 .	line of 82 clumps . . .	3·6	
	Co. 281 .	„ 107 „ . . .	4·7	
	Co. 250 .	„ 90 „ . . .	1·1	
	Co. 273 .	„ 77 „ . . .	1·3	
	Co. 213 .	„ 85 „ . . .	0	
	Co. 275 .	„ 84 „ 88 „ . . .	0	
	Co. 280 .	„ 104 „ . . .	0	
	Co. 286 .	„ 94 „ . . .	0	
	Co. 290 .	„ 95 „ . . .	0	

This amount of natural spread of mosaic disease in 1927 in Pusa is different from that in a similar experiment in Coimbatore. The Government Mycologist showed two plots in which a row of each of 24 varieties of non-mosaic thick canes was grown interstripped with alternate rows of mosaic Red Mauritius in the one plot and of mosaic Java Hebbal in the other. Thirty setts had been planted in each row. Taking the average of corresponding rows in the two plots, it was seen that in P. O. J. 2727, Fiji C, Q 813, Tanna, B 147, B 3412 under 50 per cent. of clumps had become infected, in B 6308, B 208, Fiji B, J 247, Chittoor Poovan, Java Hebbal, Batjan, Vellai and Purple Mauritius from 50 to 80 per cent. and in B 6450, Poovan, D 625, D 131, D 1135, M 55, Q 116 and Red Mauritius 80 to 100 per cent. Thus the amount of spread on thick canes in Madras is far greater than that on thin canes in Bihar when the canes are situated in the best position for the spread of the infection, as they were in the experiments immediately under review.

(*iv*) *Occurrence of mosaic disease on maize.* During August 1927 nine maize plants within 30 yards of plots Nos. 2 and 3 developed mosaic mottling on their leaves. Three hundred acres of maize on the farm were carefully examined but no other case was found. Fields round Pusa for a mile or two and along three roads to a distance of 15 miles were examined but no mosaic disease was found on maize, *Andropogon Sorghum*, *Eleusine coracana*, *Panicum frumentaceum*, *Setaria italica*, *Cynodon dactylon* and other grasses. It seems clear that these nine maize plants were infected from the infected cane in the adjacent experimental plot and that mosaic is not on the common cereals of the *kharif* crop in the vicinity of Pusa. Both maize and *Sorghum* have been infected artificially from sugarcane and the former naturally, so there is a possibility that mosaic disease will pass from cane to these two crops. This it has done already in some other countries, such as the United States, Porto Rico, Hawaii, Trinidad, Queensland and South Africa and in some of them recommendations not to grow these crops in rotation with sugarcane have been made. Maize is a common crop in some cane-growing areas of northern India and Sorghum in tropical India. If mosaic disease is going to pass to these two crops and they become infected to any great extent, not only will there be an additional problem to solve but that on sugarcane will become more complicated. Seeing that maize and sorghum are now known to be susceptible to mosaic disease in India, it seems just as likely that they will become infected as that sugarcane has, so that the danger is a real one.

(*v*) *Infection experiments.* Similar infection experiments to those of last year were repeated with confirmatory results. In addition the disease has been transmitted from Co. 213 to Co. 205, Co. 232, Co. 275 and Red Mauritius, from Co. 205 to Co. 213, Co. 275, Co. 210 and Uba, from Co. 232, Co. 287, and Co. 210 to maize, from maize to maize and from Co. 232 and Co. 205 to *Andropogon Sorghum*. In each case a number of plants equal to or greater than those being infected were used as controls. The number of such plants that have been pricked, pricked over distilled water and pricked over juice of leaves from cane whose leaves show no mottling is quite large and in no case have mosaic symptoms appeared.

Infection experiments.

——	No. of shoots inoculated	No. of shoots showing mosaic	Date	Incubation period in days
Co. 213 to Co. 213 . .	11	2	16-6-27	26
Co. 213 to Co. 205 . .	6	2	16-6-27	27

Infection experiments—contd.

——	No. of shoots inoculated	No. of shoots showing mosaic	Date	Incubation period in days
Co. 213 to Co. 232 . .	4	1	16-6-27	37
Co. 213 to Co. 275 . .	8	3	16-6-27	33
Co. 213 to Red Mauritius .	1	1	16-6-27	26
Co. 205 to Co. 213 . .	30	2	18-6-27	25
Co. 205 to Co. 275 . .	10	1	22-6-27	33
Co. 205 to Co. 210 . .	10	9	22-6-27	33
Co. 205 to Uba . . .	4	1	22-6-27	33
Co. 210 to Co. 210 . .	10	4	24-6-27	25
Co. 205 to Maize . . .	60	1	20-7-27	26
Co. 232 to Maize . . .	61	9	20-7-27	14
Co. 287 to Maize . . .	60	6	22-7-27	12
Co. 210 to Maize . . .	56	10	23-7-27	11
Maize to Maize . . .	61	42	10-8-27	11
Maize to Maize . . .	6	2	19-8-27	6
Co. 232 to Jowar . . .	4	1	18-6-27	21
Co. 205 to Jowar . . .	4	2	18-6-27	10

The Uba cane above mentioned was got from Aligarh and is the cane commonly so named in the United Provinces. Uba is supposed to be immune but a rare case of infection was found by Yoder[1] on Uba at Cairo Ga. in the United States of America in 1925.

(3) *Wilt disease of Cajanus, cotton and sesamum.* A twentieth acre plot was divided equally into three parts and sown with *Cajanus*, cotton and sesamum. There were three such plots. A large amount of culture of *Fusarium vasinfectum* from *Cajanus indicus* was broken up in distilled water and in one plot when the plants were six inches high the soil round each plant was drenched with the suspension. This culture tested on young plants in the laboratory was parasitic. Similarly another plot was treated with *Fusarium vasinfectum* from cotton. This strain was received from the Cotton Mycologist, Dharwar, as a parasitic strain. The third plot was untreated. No plant became infected.

[1] Yoder P. A. Rare cases of Mosaic Disease in Highly Resistant Varieties of Sugarcane. *U. S. A. Dept. Agri Dept. Cir.* 392, page 3, 1926.

The land had a low moisture content and the rainfall was deficient. This season also had the least amount of wilt of *Cajanus* on the farm for nine years.

(4) *Piper betel.* The disease did not appear in any of the six places where experimental plots were laid down to investigate the possibility of checking it nor was the disease reported from the delta. A comparison of a culture of the species of *Phytophthora* responsible for the disease in the Madras Presidency shows that in morphological characters, it is very similar to that of the *Phytophthora* from Bengal. Oospores, however, havé not been seen in either case. The species from Malay kindly sent by Mr. A. Thompson, has not produced sporangia on the culture media but does so very sparingly in water. During the monsoon comparative infection experiments will be carried out on the Bengal varieties of betel.

(5) *Cinchona.* A species of *Phytophthora* was isolated from dying seedlings of cinchona brought from Mungpoo. On three occasions during October and November fifteen seedlings were inoculated with a pure culture of the fungus and five were kept as controls. The seedlings had from 6 to 9 leaves and the infection material was placed on the apical bud. Nine, fifteen and ten seedlings respectively became infected and died in three days while the fifteen control plants remained healthy. Twelve plants three feet high inoculated at the apical bud and on the stem did not become infected. Further work will be done on the estate. The average of 400 sporangia of this *Phytophthora* is $52\times33\mu$ and the range is $30—79\times21\cdot6\text{-}45\mu$. The papilla is large and prominent. Chlamydospores measuring 38μ are present but no oospores.

(6) *Cicer arietinum.* After a period of wet misty weather from the 20th January to the 15th February a leaf-disease appeared for the first time on the pure line plots in the Botanical Area in Pusa. The affected plots were YG 7, 13, 15, 26, 31, 32, 34, 38, 40, B.G. 1, 5, 10, 11, 12, 17 and P. 39. B.G. 10 and 11 and P. 39 were so badly infected that they were pulled up in order to reduce the spread of infection to other plots. Circular spots 0·5 to 4 m.m. in diameter occur on both sides of the leaflet. They are yellow brown with a pale reddish margin and sometimes coalesce. The leaflets become brown and fall off. Dark brown conidia and conidiophores cover the surface of the spot giving it a blackish appearance. The conidia are single, ovate, muriform and measure $13\text{-}33\times9\text{-}26\mu$, the average being $22\times19\mu$. The fungus is a species of Mystrosporium. The results of the work on gram wilt and linseed wilt are like those of last year. The two strains of *Fusarium* isolated from gram, however, have not proved pathogenic.

(7) *Sesamum indicum.* Specimens showing malformation and proliferation of the young shoots were received from three agricultural stations in Burma. *Sclerotium bataticolum* and a mite were found.

The fungus in culture did not infect well grown plants but this will be tried in the coming season. It seems to be likely that the mite is the cause.

(8) *Sterility of rice grains.* This year's experiments with the *Fusarium* from Assam failed to cause complete sterility and further work will be done in the field with proper precautions in order to eliminate the possible effect of growing the plants in pots.

A species of *Cephalosporium* isolated from the specimens from the Punjab killed seedlings and caused a rot at the collar of grown plants. The cultural characters of this fungus agrees with those of the former except in the absence of macroconidia.

(9) *Smut on Kodra* (*Sorosporium Paspali* McAlp. on *Paspalum scrobiculatum*). Field work carried out by the post-graduate student showed that the methods of prevention worked out in the laboratory of steeping in copper sulphate and dusting with copper carbonate were applicable there in reducing the amount of smut from about 50 per cent. on grains infected before sowing to less than 1 per cent. on grains similarly infected and treated.

(10) *Rust of wheat* was severe this season. The following table shows the comparative incidence on country wheat which was badly attacked, on Pusa 4 and Pusa 12 which were the least attacked and on Pusa 12 and Pusa 80-5 which were the worst attacked of the Pusa wheats.

——	*P. triticina* Orange rust	*P. glumarum* Yellow rust	*P. graminis* Black rust
Country	B + 100	M + 40	M — 25
Pusa 4	M + 40	0	L + 10
Pusa 52	M + 40	B + 100	L — 5
Pusa 12	B + 100	0	M +40
Pusa 80-5	B + 100	0	L + 10

The letters B, M and L indicate a bad, medium and light attack and correspond to Cobb's standard. If B+ be taken arbitrarily as 100 then the other figures represent the amount of rust relative to this standard. The bushel weight of the four main Pusa wheats in the botanical area were as follows :—

——	Pusa 4	Pusa 52	Pusa 12	Pusa 80-5
1926 . . .	64·9	65·5	61·5	65·1
1927 . . .	63·0	63·0	65·0	66·5
1928 . . .	63·2	62·1	56·0	55·9

The crop of Pusa 4 in 1928 was grown not in the botanical area but on the Farm. Orange rust came early and was the worst while black rust came late in the season. It was the former that caused the greater part of the loss in crop.

This outbreak of rust is corelated with unusual dull, wet, misty weather from the 19th of January to the 5th of February during and after which time rust which had first appeared in small quantity at Christmas developed rapidly.

IV. Systematic work.

During the year under report 40 calls were received from different places to examine diseases of crops and to give advice. Among these *Plasmodiophora Brassicae* on cabbage and cauliflower, *Uredo tephrosiicola* on *Tephrosia candida* and *Cephaleuros mycoidea* on apple twigs were recorded for the first time. The herbarium material of the genus *Cercospora* was specially studied. Cultures and specimens were supplied to Dr. Bose, Carmichael Medical College, Calcutta ; Mr. A. Sawhney, Punjab University ; Dr. Chowdhury, University of Lucknow ; Dr. Uppal, Plant Pathologist, Bombay ; Mr. Mundkur, Cotton Research Laboratory, Dharwar ; Mr. C. M. Tucker, Plant Pathologist, Porto Rico ; Miss. Hunter, University of Toronto ; Dr. F. P. MacWhorter, Virginia Truck Experiment Station ; Mr. G. L. Zundel and Dr. G. P. Clinton, Connecticut Experimental Station ; Dr. J. L. Waterhouse, Sydney University ; Professor Brown, Imperial College of Science, London ; and the Imperial Bureau of Mycology, London.

V. Programme of work for 1928-29.

1. *Research work.* New diseases of Indian crops that come to the notice of the Section will be investigated. The following crop diseases will receive special attention :—

(*a*) Diseases of cereals.
(*b*) Diseases of sugarcane.
(*c*) Diseases of *rahar*.
(*d*) Diseases of betel-vine.
(*e*) Diseases of cinchona.
(*f*) Diseases of gram.

2. *Training.* Students and assistants will receive training on the lines indicated in the prospectus.

3. *Routine work.* Advice and assistance as required will be given to other departments and the general public.

VI. Publications.

McRae, W. . .	Report on Mycology, 1927-28, for the Committee of the Privy Council for Scientific and Industrial Research.
McRae, W., and Subramaniam, L. S. .	Further study on mosaic disease of sugarcane. *Agri. Jour. India,* XXIII, Pt. IV, 1928.
Mitra, M. . . .	Gall-formation on the roots of mustard due to a smut. *Agri. Jour. India,* Vol. XXIII, Pt. II, 1928.
Subramaniam, L. S. .	Root-rot and Sclerotial diseases of wheat. *Pusa Bull. No.* 177.
Mohammad Taslim .	Stem-rot of Berseem caused by *Rhizoctonia solani* Kuhn. *Pusa Bull. No.* 180.

REPORT OF THE IMPERIAL ENTOMOLOGIST.

[P. V. Isaac, B.A., M.Sc., D.I.C.]

I. Administration.

Mr. T. Bainbrigge Fletcher held charge of the Section from 1st July 1927 until his going away on leave on average pay for four months with effect from 4th May 1928, and for the rest of the year under report Mr. P. V. Isaac, Second Entomologist (Dipterist), officiated as Imperial Entomologist.

Rai Bahadur C. S. Misra held charge of the current duties of Second Entomologist, in addition to his own duties as First Assistant, while Mr. P. V. Isaac officiated as Imperial Entomologist.

II. Training.

1. Mr. Karam Singh Lamba, M.Sc., Post-graduate student, was admitted on 2nd November 1927.

2. Mr. Ram Narain Singh, L.Ag., Entomological Assistant, United Provinces, was admitted on 1st July 1927 for a special two years' course in Systematic Entomology at the request of the Government of the United Provinces.

3. Mr. Peare Mohan, M.Sc., a student deputed by the Indian Central Cotton Committee, was admitted on 7th June 1928 as a short course student for one year.

4. Messrs. Pashupati Roy and Sulaiman Mian, students from Bengal, were given training in lac cultivation during the year, at the request of the Director of Agriculture, Bengal.

III. Insect Pests.

Sugarcane. Termites were causing much damage in the cane experimental plots. Sixty days after the planting of sets 12·5 per cent. of the young plants were dead. Trenches were dug in the experimental area, and filled with dry grass to attract termites. After a few days the grass was set on fire. This method destroys a large number of termites. The same plots were also irrigated with water charged with crude-oil emulsion. This prevented further damage to the plants. Experimental planting of Co. 205 and Co. 213 were made with the object of studying the influence of borer attack and the consequent loss. *Scirpophaga nivella*, Fb., caused a maximum of 19·5 per cent. of dead hearts in Co. 213 and 14·7 per cent. in Co. 205. Numerous reports of damage by *Scirpo-*

phaga nivella were also received from cane plantations in Bihar. From two egg-masses of this insect collected from the fields, 1,666 borers hatched out. Under field conditions eggs are laid during the middle of March and again at the end of June. Later, overlapping generations follow. The egg parasites appear at the end of June. A study of the egg parasitization of *S. nivella* was taken up and it appeared that the use of egg parasites would be the most effective method of checking the borer. *Tanymecus sciurus*, Oliv., was reported damaging the leaves of cane in Bihar. Ratoon canes were infested heavily with *Pseudococcus* spp. A detailed study of the sucking insects found on cane and their possible connection with the transmission of the Mosaic and Streak diseases was taken up. Hitherto *Pseudococcus* spp., *Aphis sacchari*, Zehnt., *Pyrilla* spp., *Assamia* (*Phenice*) *mœsta*, Westw., and *Neomaskellia bergii*, Sign., have given negative results. The Aphis which occurs here on maize and sorghum was identified as *Aphis maidis*, Fitch, which causes mosaic in other countries.

Rice. Examinations of rice stubble were carried out frequently to ascertain the percentage of stems that carried over hibernating larvæ from one season to the following season. 360 stubbles examined had 2,663 stems, of which 42 were found to have been bored. There were only four healthy borers in them. This makes the percentage 0·15. Dr. S. Kinoshita, Chief Entomologist, Agricultural Experiment Station, Tokyo, who came specially to study the rice pests and their parasites, was given every facility during his stay of four weeks at Pusa.

Cotton. Cotton shoots were badly affected by *Pseudococcus corymbatus*, Gr., which was parasitized by *Gitonides perspicax*, Dyar. This parasite was bred also from *Monophlebus octocaudata*, Gr.

The study of the habits and life-history of the Braconid (? *Loxocephalus* sp.) which is parasitic on adult weevils of *Myllocerus 11—pustulatus* var. *maculosus*, Fst., was continued. Several efforts were made to get the weevils parasitized in captivity, but they all proved fruitless, for the reason that when male adult parasites emerged in the cage, there were no females, and *vice versâ*. At last in March 1928, two females and one male emerged within three days interval of each other, and all these were liberated in a cage which contained weevils that had long been in captivity. For some unaccountable reason the parasites died within two days, but on dissecting the weevils, primary larvæ of the parasite were found in two of them. The new facts brought to light during the year under report are :—

(1) The adult parasites are active at Pusa till early April and do not disappear after the first week of February, as hitherto believed.
(2) In early stages the parasitic larva is very different in appearance to the larva of the later stages.

(3) A nearly full-grown larva exhibits two pairs of peculiar leg-like protuberances, which are not usually found in other Hymenopterous larvæ.

Other Crop pests. A study of the alternative host plants of some of the common insect pests was made with the following results :—

1. *Acherontia styx*, Westw. Larvæ feeding on *Millingtonia hortensis.*
2. *Laphygma exigua*, Hb. Larvæ feeding on leaves of *Anagalis arvensis.*
3. *Prodenia litura*, Fb. Larvæ feeding on *Rumex maritimus.*
4. *Papilio demoleus*, Linn. Larvæ feeding on leaves of *Feronia elephantum.*
5. *Leucophlebia lineata*, Westw. Larvæ feeding on leaves of *Imperata arundinacea.*

Larvæ of *Bedellia enthrypta*, Meyr., were found mining the leaves of *Porana paniculata. Acrocercops* sp. was found mining Loranthus leaves. The eggs of *Eupterote undata* were found on *Bombax malabaricum* leaves ; the life-cycle was found to take a whole year. *Diacrisia obliqua* was bad on groundnuts on the Farm. Cauliflower and cabbage were again damaged by *Hellula undalis. Brachytrypes portentosus* damaged chillies. The Pyralid *Cœnodomus hockingii*, Wlsm., was reared from caterpillars feeding on *Feronia elephantum* at Kalimpong. *Ancylis lutescens*, Meyr., was bred in numbers from *Ber* fruits along with *Meridarcheis scyrodes* Meyr. *Hieromantis ioxysta*, Meyr., was bred from larvæ mining the tender leaves of *Schleichera trijuga. Gelechia tamaricella*, Z., was reared from *Tamarix gallica* leaves. It was heavily parasitized by a Bethylid, which has been studied. A Tipulid, *Libnotes rufa*, Meij., was reared from decomposing matter in the burrows of a Cerambycid borer in Jak trees.

Pathological Entomology. The study of the life-histories of the Tabanidæ was continued. The Simulidæ, Culicidæ, Ceratopogoninæ and Mycetophilidæ in the collection were examined and consignments of some of these were sent to outside workers for exact determination. The campaign on Pusa Estate for the reduction of mosquitos was kept up. Some Tabanidæ and Trypetidæ were identified for correspondents.

At the request of the Director of Agriculture, Punjab, Mr. P. V. Isaac conferred with him regarding a suitable organization for the Fly survey in the Punjab and research on Surra.

Stored grain. Another year's work on the storage of wheat under mercury vapour indicates that the method is quite satisfactory for household purposes. By this method wheat is effectively protected against the ravages of the wheat weevil (*Sitophilus oryzae*). Bruchid beetles did not attack gram stored in this way and when gram already infested with Bruchids was stored with mercury, all further breeding of the pest

stopped. Wheat stored under mercury vapour has been used by a family at Pusa for the last three years, with no deleterious effects on the health of the consumers.

In order to allay popular sentiment against the use of liquid mercury, a tin amalgam of mercury was also tried. The results so far have been satisfactory. It was found that the grain treated with mercury was not at all affected as regards its germinating power, as the following figures will show.

——	Date	Without mercury (control) 100 grains	With mercury 100 grains	With mercury tin amalgam 100 grains
Pusa wheat No. 12 . .	7-XI-27 to 12-XI-27	77	86	77
Pusa wheat No. 4 . .	10-XI-27 to 14-XI-27	75	92	92
Pusa wheat No. 12 . .	19-XI-27 to 23-XI-27	73	79	73

Locusts. A swarm of locusts—*Schistocerca gregaria*, Forsk., had visited Pusa on the 28th June 1927. After this, during the year under report, another swarm visited the locality on the 11th July 1927. Only *Ficus religiosa* and *Dalbergia sissoo* were defoliated to some extent by these.

IV. Bees and Lac.

Apiculture. Numerous enquiries were received from different parts of India. The public continued to take much interest and several requests for hives, foundation combs and queen excluders were complied with.

Lac. The emergence of lac larvæ at Pusa took place on the following dates :—

Ber lac	17th October 1927. 14th June 1928.
Palas lac	11th October 1927 21st June 1928.
Kusum lac	5th November 1927. 6th June 1928.

A number of *Palas*, *Ber*, *Kusum*, *Ghont* (*Zizyphus xylopyra*), *Acacia catechu* and *Acacia farnesiana* trees were planted in the experimental

plots at Pusa. A superior variety of grafted *Ber* was also planted to test its suitability for lac culture. Brood lac was supplied in quantity to the All-India Lac Company, Calcutta.

A revised fourth edition of the Lac Bulletin was sent to the press in May 1928.

V. Protection from Foreign Insect Pests.

Large quantities of American cotton were imported into Bombay during the year. At the instance of the Indian Central Cotton Committee, Rai Bahadur C. S. Misra and a Fieldman were deputed to Bombay to examine some of the imported bales for boll-weevil—*Anthonomus grandis*, Boheman. They found no live weevil. Considering what a dangerous pest this insect is, it is necessary to employ the most reliable means for preventing its entry into India.

Suckers of date palms obtained by the Department of Agriculture, Punjab, from Mesopotamia in October 1927, and distributed after fumigation at Lyallpur, to certain stations in British India and some Indian States, were reported later to be infested with a Longicorn borer *Pseudophilus testaceus*, Gahan—a serious pest of date palms in Iraq and not known in India. On examination by Assistants sent from here during June 1928 a live grub of the borer was found in one of the plants at Charsada, near Peshawar, and apparent signs of recent damage by the borer were noticed in a place near Bannu, N. W. F. Province, and at Shikarpur in Sindh. It was suggested that all the suckers belonging to the above consignment should be destroyed without delay.

VI. Insect Survey.

Collections were sent out for identification to the following specialists and their help is gratefully acknowledged :—

1. Chrysomelidæ and other Coleoptera—Imperial Bureau of Entomology.
2. *Aphididæ* on cereals—Imperial Bureau of Entomology.
3. *Carabidæ*—Mr. H. E. Andrewes.
4. *Scoliadæ* (with a few specimens of *Siricidæ*)—Professor Chester Bradley.
5. *Geometridæ*—Mr. L. B. Prout.
6. Orthoptera—Dr. B. Uvarov.
7. Microlepidoptera—Mr. E. Meyrick.
8. *Noctuidæ*.—Miss A. E. Prout.
9. *Buprestidæ*—Mr. K. G. Blair.
10. *Mantidæ*—Imperial Bureau of Entomology.
11. *Culicidæ*—Capt. P. J. Barraud.

12. *Monophlebus* spp.—Mr. E. E. Green.
13. *Braconidæ*—(*Apanteles and Microgaster* spp.)—Imperial Bureau of Entomology.
14. *Ephemeridæ*—Zoological Survey of India.
15. *Thysanoptera* (Duplicates)—Dr. T. V. Ramakrishna Ayyar, Coimbatore.
16. *Catharsius* spp. and other Coleoptera—Mr. G. J. Arrow, British Museum.
17. *Mycetophilidæ*—Dr. C. F. Adams, Indianapolis, U. S. A.
18. *Heteroceridæ*—Dr. Richard Mamitza, Austria.
19. *Dytiscidæ*—Herr Zimmermann, Germany.
20. *Simulidæ*—Dr. I. M. Puri, Kasauli.

Specimens received from numerous correspondents were identified and returned: chief among them are:—

	Consignments.
1. Government Entomologist, Madras	3
2. „ „ U. P.	1
3. „ „ Punjab	1
4. Assistant Entomologist, C. P.	1
5. Curator, Darjiling Museum	2
6. The Chief Commissioner, Andaman and Nicobar Islands	1
7. Director, Indian Lac Research Institute	1
8. Assistant Superintendent, Zoological Survey of India, Indian Museum, Calcutta	1

Requests from other Entomologists for Indian insects were complied with, as far as possible, and the following specimens were supplied:—

1. *Vespa orientalis*—Mr. Mellor, Cairo, Egypt.
2. *Apis indica* and *Apis florea* (Drones) *Apis dorsata* (males and workers)—Dr. Prell, Tharandt, Germany.
3. *Croce filipennis.*—Prof. G. C. Crampton, America.
4. *Rhyssa persuasoria* and its *Siricid hosts.*—Mr. D. S. Wilkinson, London.
5. *Myiopardalis pardalina*—Director, Bureau of Applied Entomology, Petrograd.
6. *Chilo oryzae*—Mr. S. A. Rohwer, America.
7. Insects, representative of larger Orders—Prince of Wales Medical College, Patna.
8. Insects, representative of Orders—Headmaster, Agricultural School, Dacca.
9. Borers in Rice—Dr. S. Kinoshita, Chief Entomologist, Agricultural Experiment Station, Tokyo, Japan.
10. *Pyrgomorpha* spp. *and Atractomorpha* spp.—Prof. J. J. Asana, Ahmedabad.

The collections were carefully looked after. The Orthoptera were transferred into new cabinets. Many insects are still kept in old store boxes which are very unsatisfactory for keeping specimens.

VII. Catalogue of Indian Insects.

The following Catalogues were published during the year ended June 1928.

Part 13—Cicindelidæ, by Mercia Heynes-Wood and Cedric Dover.
,, 14—Palpicornia, by A. d'Orchymont.
,, 15—Cecidomyidæ, by Ronald Senior-White.
,, 16—Cosmopterygidæ, by T. Bainbrigge Fletcher.
,, 17—Yponomeutidæ, by T. Bainbrigge Fletcher.

VIII. Programme of Work for 1928-29.

Major.

This will be on lines similar to those followed in current year and special attention will be paid to the investigation of the pests of crops, chiefly sugarcane, rice and cotton. Investigations that will help in the protection of fruit trees, stored grain and domestic animals from insects pests will also receive attention.

Minor.

This will include the publication of papers that further our knowledge of Indian insects or give such other information as will be helpful in checking the damage done by insects. The collection of Indian insects and their identification as far as can be done by the Pusa staff or with the help of outside specialists will be carried out. The Cataloguing of Indian Insects will receive attention. Advice on Entomological topics will be given to all enquirers and when required to Provincial Departments and other Research Institutes. The training of students in Entomology will also form part of the work.

IX. Publications.

The following publications, either prepared by the Pusa staff or founded in whole or in part on material sent from Pusa, have actually been issued during the year ended 30th June 1928 :—

Ballard, E. . . Indian Miridæ (Capsidæ. (*Ind. Agr. Ent. Mem.*, X, pp. 61-68, Sept. 1927.)

Dutt, G. R. . . Aphids and Lady Bird beetles. (*Agri. Jl. Ind.*, Aug. 1927.)

FLETCHER, T. BAINBRIGGE An Aphidid on Sugarcane roots, new to India. (*Agri. Jl. Ind.*, Aug. 1927.)

" " " Cosmopterygidæ. (*Cat. Ind. Ins.*, Part XVI.)

" " " Yponomeutidæ. (*Cat. Ind. Ins.*, Part XVII.)

" " " A Veterinary Entomology for India—II. (*Jl. Centr. Bur. Anim. Husb. Dairying India*, I, 69-81 ; July 1927.)

" " " A Veterinary Entomology for India—III. (*Jl. Centr. Bur. Anim. Husb. Dairying India*, I, 112-118 ; Oct. 1927.)

" " " A Veterinary Entomology for India—IV. (*Jl. Centr. Bur. Anim. Husb. Dairying India*, I, 175-177 ; Jan. 1928.)

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REPORT OF THE IMPERIAL AGRICULTURIST.

(G. S. Henderson, N.D.A., N.D.D.)

I. Charge.

Mr. G. S. Henderson, N.D.A., N.D.D., was in charge of the Section throughout the year under report. He was appointed a Member of the Government of India Committee on Opium from November 1927 to April 1928 in addition to his own duties.

Mr. Arjun Singh Maan, L. Ag., Assistant to the Imperial Agriculturist, remained in charge of the current duties of the Imperial Agriculturist, in addition to his own, during the absence of Mr. Henderson as a Member of the Opium Committee.

Mr. L. S. Joseph, Cattle Superintendent, was in charge of the cattle-breeding operations throughout the year, while Mr. Jamaluddin, Second Cattle Superintendent, remained in charge of the dairy.

Mr. Aga Md. Mustafa, B.A. (Oxon), Agronomist, was appointed to act as Agricultural Officer, North-West Frontier Province, in September 1927.

II. Touring Publication Advisory work and Seed distribution.

The Imperial Agriculturist was absent from Pusa on tour during the greater part of the year. Along with the Opium Committee he toured extensively in Central India and Rajputana. He was present at two meetings of the Advisory Committee of the Lac Research Institute at Ranchi and advised on the cultivation of the experiment plantation. He visited Assam at the request of His Excellency the Governor to advise on the cattle policy for the province. The cattle farms at Bangalore and Wellington were visited in conjunction with the Imperial Dairy Expert. General advice on agriculture was given and the live-stock was valued for audit purposes. The Bundi State was visited during the year in connection with a scheme for river "bunding" and the reclaiming of waste land by modern methods of agriculture. Simla was visited for the final discussion and signature of the report of the Opium Committee in June 1928.

A bulletin was issued on the "Unit System of Farm Buildings" and various articles were published in "The Agricultural Journal of India" and "The Journal of the Central Bureau for Animal Husbandry and Dairying in India."

Enquiries by post are increasing considerably, showing that there is an awakening of public interest in agriculture. Nearly a hundred private and government bodies asked advice on general agricultural subjects such as crops, cultivation, manures, fodder production, management of cattle, farm machinery and farm buildings.

The number of persons to whom seed, etc., were distributed has increased and the list is too long for publication. Among the major articles of distribution were oats 103 md. and sugarcane 437 md. Besides these seeds which were produced on the Pusa Farm, enquirers were put in touch with sources of supply of reliable seed and implements when possible.

III. Training.

Six post-graduate students completed their training in general agriculture and cattle-breeding in March 1928. Four post-graduate students of the second year were admitted for training in April 1928.

Dr. Rama Rao from the Hyderabad State studied fodder production on the farm.

IV. Pusa farm and cultivation.

Season. The total rainfall during the year from the 1st June, 1927, to 31st May, 1928, amounted to 37·17 inches as against 38·74 inches for the corresponding period of the previous year. The monsoon began with 2·40 inches of rain on the 15th June and sowings of *kharif* (summer) crops were taken in hand immediately. There was fair rainfall during July and August, but the break after 2nd September affected the maize grain crop which was just forming cobs. There was no rain in October and so there was very little moisture for *rabi* sowings, but 1·92 inches of rain in the first fortnight of November improved the situation. 1·28 inches of rain in January 1928 also did good to the oats crop, but *arhar* (*Cajanus indicus*) suffered as the flowers were shaken down. The rainfall, although smaller than the normal, was fairly well distributed and the season was on the whole good.

V. Field experiment work.

(*a*) Table I gives the results of the permanent manurial and rotation experiments for 1927-28. These series have been carried out for twenty years. Underneath the figure for 1927-28 is given the average figure for these twenty years. The results are very interesting and important. Plot No. 16 is outstanding and shows the value of the application of superphosphate to a green manurial crop.

TABLE I.

Results of permanent manurial and rotation experiment for 1927-28.

Plot No.	Treatment	A SERIES			B SERIES		
		Maize grain per acre in lb.	Oats grain per acre in lb.	Peas grain per acre in lb.	Maize grain per acre in lb.	*Arhar* grain per acre in lb.	Barley grain per acre in lb.
1	No manure	501 676	575 652	.. ..	312 510	1,096 959	.
2	Farmyard manure to supply 10 lb. nitrogen per acre.	632 825	797 737	.. ..	550 710	1,236 1,070	.. ..
3	Farmyard manure to supply 20 lb. nitrogen per acre.	797 985	895 852	.. ..	608 832	1,297 1,128	.. ..
4	Farmyard manure to supply 30 lb. nitrogen per acre.	920 1,096	985 908	.. ..	772 905	829 911	.. ..
5	Rape-cake to supply 20 lb. nitrogen per acre.	706 948	624 624	.. ..	616 795	944 886	.. .
6	Sulphate of ammonia to supply 20 lb. nitrogen per acre.	509 599	443 472	.. ..	296 504	936 868	.. ..
7	Sulphate of potash to supply K_2O as in farmyard manure No. 3.	435 554	386 432	.. ..	271 428	624 776	.. ..
8	Superphosphate to supply P_2O_5 as in farmyard manure No. 3.	591 923	912 895	.. ..	345 783	698 836	
9	Sulphate of potash to supply K_2O and super to supply P_2O_5 as in farmyard manure No. 3.	682 864	895 844	.. ..	238 753	1,150 823	.. ..
10	Sulphate of ammonia to supply nitrogen, sulphate of potash to supply K_2O and super to supply P_2O_5 as in farmyard manure No. 3.	657 984	969 908	.. ..	616 990	1,010 798	.. ..
11	No manure or leguminous crop	197 492	452 404	.. ..	213 506	.. ..	296 357
12	Green manure in a cereal rotation	. 844	731 617	.. .	706 744	.. ..	308 459
13	Deep-rooted leguminous crop in a cereal rotation.	452 598	501 467	. ..	675 519	723 698	.. ..
14	One deep-rooted and one shallow-rooted legume in the rotation.	484 636	394 336	10 143	608 582	739 639	.. ..
15	Green manure and leguminous crop in the rotation.	.. 1,013	640 653	.. ..	870 774	780 617	.. ..
16	Green manure and superphosphate to supply P_2O_5 as in farmyard manure No. 3.	.. 1,367	1,175 1,288	.. ..	1,166 1,242	345 596	.. ..

(*b*) *Wilt manurial experiments.* These experiments were carried on under the direction of the Imperial Mycologist to get data on the possibility of checking the wilt disease of *arhar* (*Cajanus indicus*). It is noteworthy that all the plots getting a dressing of superphosphate along with green manure gave well over 2,000 lb. per acre. Where the P_2O_5 was applied in the form of bonemeal, a large reduction in the yield resulted.

TABLE II.

Results of wilt manurial plots in North Pangarbi for 1927-28.

Plot No.	Treatment per acre	A SERIES		B SERIES	
		Fallow during *kharif* 1927.	Oats grain per acre in lb.	Sann-hemp for green manure during *kharif* 1927.	Oats grain per acre in lb.
1	Check—P_2O_5 60 lb.		1,725		2,258
2	P_2O_5 20 lb.		2,176		2,053
3	Check—P_2O_5 60 lb.		2,053		2,505
4	$MgSO_4 7H_2O$ 150 lb., P_2O_5 60 lb. . .		1,848		2,382
5	Check—P_2O_5 60 lb.		1,704		2,464
6	$MgSO_4 7H_2O$ 300 lb., P_2O_5 60 lb. . .		1,848		2,135
7	Check—P_2O_5 (Bonemeal) 60 lb. . .		1,540		1,642
8	$Fe_2(SO_4)_3$ 150 lb., P_2O_5 60 lb. . .		1,684		2,258
9	Check—P_2O_5 60 lb.		1,889		2,258
10	$Fe_2(SO_4)_3$ 150 lb., P_2O_5 60 lb. . .		2,053		1,971
11	Check—P_2O_5 60 lb.		2,423		2,217
12	$Fe_2(SO_4)_3$ 150 lb., P_2O_5 60 lb. . .		2,423		2,012
13	Check—P_2O_5 60 lb.		1,950		1,848

TABLE III.

Yield of arhar for wilt experiment in Punjab D Block for the Imperial Mycologist during 1927-28.

Plot No.	Variety	Yield in lb. per acre	Treatment
10 D	Arhar No. 1 P. F., treated seed .	1,289	Superphosphate at 4 cwt. per acre.
11 D	,, ,, ,, ,, ,, .	1,297	No manure.
25 D	,, ,, ,, ,, ,, .	1,585	Superphosphate at 4 cwt. per acre.
26 D	,, ,, ,, ,, ,, .	1,642	No manure.
27 D	,, ,, ,, ,, ,, .	1,560	Superphosphate at 4 cwt. per acre.
28 D	,, ,, ,, ,, ,, .	1,150	No manure.

(*c*) Three varieties of oats produced by the Imperial Economic Botanist were tried against the selected Farm oats. The results are given in

TABLE IV.

Serial No.	Oat varieties	Average yield in lb per acre from Punjab plots	Yield in lb. from one acre plot in Brickfield II
1	B. S. 19-1 N	1,547	1,484
2	B. S. 12-1 S	1,524	1,599
3	B. S. 14-2 N	1,487	1,583
4	P. F. 1	1,264	1,265*

* Average of 11 acres.

(*d*) Four varieties of wheat sent by the Botanical Section were tried and the results are given in

TABLE V.

Varieties	Highest outturn in lb per acre	Average outturn in lb. per acre
Wheat Pusa 4	977	748
Wheat Pusa 12	1,462	969
Wheat Pusa 52	1,790	1,513
Wheat Pusa 80-5	1,511	1,215

(*e*) *Kharif fodder pulses.* The following Table gives outturns of selected *kharif* pulses. These pulses are used in the general rotation of the farm and supply green fodder for the pedigree dairy herd to graze on.

TABLE VI.

Serial No.	Name of pulses	Highest outturn of seed in lb. per acre	Highest outturn of green fodder in lb. per acre.
1	Soybean (*Glycine hispida*)	739	7,555
2	Cowpeas (*Vigna catjang*)	813	7,900
3	*Meth* (*Phaseolus aconitifolius*) . . .	1,215	12,072
4	*Guar* (*Cyamopsis psoralioides*) . . .	895	9,058

(*f*) *Minor trials.* Trials were conducted with Farm selected seed of gram, peas, *arhar* and chillies ; also with mustard, sarson and foreign oats. Scotch "Potato" oat is useful for fodder purposes only and requires a considerable amount of moisture.

A number of fodder grasses were on trial, but they only grow well during the monsoon period.

VI. Fertility Experiments.

These experiments on the upkeep of fertility under heavy cropping have been carried on for 16 years on an area of some 413 acres. The rotation is as follows :—

Seasons of the year	First year	Second year	Third year
Kharif . .	Maize for silage .	Maize for grain .	*Kharif* pulse.
Rabi . .	Oats . . .	*Arhar* . . .	Oats.

Table VII.

Yield of 13 fields (413 acres) for the last 16 years.

Year	Annual rainfall	Oats and other cereals	Maize	Pulses	Total grain	Green stuff for fodder and silage
		Md.	Md.	Md.	Md.	Md.
1912-13 . .	41·26	2,210	522	894	3,626	16,301
1913-14 . .	61·74	1,997	200	1,100	3,297	11,513
1914-15 .	54·88	1,749	534	704	2,987	14,427
1915-16 . .	51·37	2,669	884	701	4,254	36,903
1916-17 . .	59·67	2,897	670	932	4,499	31,971
1917-18 . .	45·54	2,376	1,276	1,010	4,662	30,893
1918-19 . .	60·19	3,386	559	1,037	4,982	30,735
1919-20 . .	32·73	2,479	1,064	719	4,262	31,624
1920-21 . .	44·33	2,542	766	1,073	4,381	33,359

TABLE VII—*concld.*

Yield of 13 fields (413 acres) for the last 16 years.

Year	Annual rainfall	Oats and other cereals	Maize	Pulses	Total grain	Green stuff for fodder and silage
		Md.	Md.	Md.	Md.	Md.
1921-22 . .	39·82	3,754	1,267	1,132	6,153	34,492
1922-23 . .	65·78	3,752	496	941	5,189	23,021
1923-24 . .	24·88	2,448	988	1,100	4,536	29,146
1924-25 . .	57·00	5,816	467	1,234	7,517	20,936
1925-26 . .	48·67	4,611	343	1,030	5,984	22,906
1926-27 . .	38·74	4,131	540	512	5,183	21,293
1927-28 . .	37·17	4,283	957	649	5,889	26,459

It will be seen that the total yield of grain from this area of land shows a steady upward tendency with minor seasonal fluctuations due chiefly to rainfall.

Another striking fact is the effect on the succeeding oat crop in the year when the *kharif* pulse is grazed by cattle. In 1925-26, Phatak and Nepauli fields each averaged 17 md. oats per acre. In 1927-28 with a smaller rainfall these fields, after the pulse was grazed, averaged 21 md. and 22 md. respectively per acre of oats. These differences are remarkably consistent and are of considerable practical importance showing that it is possible to maintain fertility by grazing cattle on leguminous catch crops and combine cattle rearing with intensive cultivation while increasing the value of the land.

VII. SEED SELECTION.

An important part of the work on the Farm which has been carried out for a considerable time is the selection of good seed of the staple crops usually grown on the Farm. The best results so far have been obtained with maize, *arhar*, chillies, oats and peas. Three strains of maize suitable for different conditions are under cultivation and distribution has now begun to growers in the districts. Maize P. F. 2 is early ripening, of a yellow colour and is likely to be in considerable demand.

VIII. Manurial Experiments.

The chief manurial experiments were done on cane, and the results are given under that head. On the Farm area it was found that with oats an application of one maund of calcium cyanamide *plus* one maund of superphosphate as against one maund of superphosphate alone showed an increase of 20 per cent. of threshed oats grain.

IX. Crops.

Oats. The best yield per acre in this crop was 24½ md. from a 17-acre field. The average over 255 acres was just under 17 md. per acre.

Maize and leguminous fodder crops. These gave a good yield and sufficient fodder was available all the year round for the cattle. 21,000 md. of maize silage was made in pits. The regular cycle for cattle grazing is as follows :—

Cold weather—Berseem.
Hot weather—Maize and *meth* irrigated.
Rains—Maize, *guar* and *meth* unirrigated.
Late sown *meth* and soybean are available to carry on the grazing till the berseem is ready in November.

Sugarcane. The New Area of about 160 acres is primarily intended for sugarcane growing. This land is divided into three blocks of some thirty acres each, so that a compact area of cane is available each year. The fertility of the land is kept up by irrigated catch crops and young bulls are sent from the pedigree herd to graze. This area also enables the young bulls to be kept till they come to a breeding age. A properly fenced nursery has been made for the preliminary trials of hybrid canes sent from Coimbatore. In addition to the work on the New Area, ten acres of land on the main Farm are kept for varieties to be tested on a larger scale under conditions likely to be experienced in North Bihar when sent to outside growers. Work on sugarcane in 1927-28 chiefly consisted of the following :—

1. Seasonal trials,
2. Manurial experiments,
3. Varietal tests,
4. Propagation of new varieties in nursery,
5. *Gur* making, and
6. Investigations in mosaic disease and insect pests.

(1) *Seasonal trials.* Coimbatore varieties Nos. 205, 210 and 213 were planted in October 1926 and February 1927 in Block II, New Area, with similar treatment. The results obtained are shown in the following Table.

TABLE VIII.

Variety of cane	Outturn of stripped cane per acre in Md.	CHEMICAL ANALYSIS					Average weight of cane in lb.	REMARKS
		Juice per cent. on cane	Brix per cent.	Sucrose per cent.	Glucose per cent.	Purity per cent.		
Co. 205, October	615	63·28	16·97	13·46	1·34	79·33	1·42	Analysed on 21-11-27.
Co. 205, February	567	61·88	17·49	14·04	1·20	80·27	1·45	
Co. 210, October	573	61·10	17·04	13·77	0·47	80·83	1·96	
Co. 210, February	678	59·24	15·92	12·67	0·55	79·58	1·80	
Co. 213, October	581	65·26	16·46	13·41	0·96	81·44	2·57	
Co. 213, February	605	63·15	17·94	15·36	0·86	85·61	2·31	

(2) *Manurial experiments.* In conjunction with the Imperial Agricultural Bacteriologist 10½ acres of fairly uniform land in Block II were divided into 21 one-fourth acre plots. Co. 213 variety of sugarcane was grown. The cane was planted in February 1927 and harvested in January 1928. The general scheme and outturn from individual plots is given below to nearest maund.

TABLE IX.

Plot No. .	3	4(S)	1	2	3	1	2
Md. .	276	239	137	252	310	224	196
Plot No. .	2s	3s	4(S)	1s	2s	3s	1s
Md. .	224	278	260	271	304	286	220
Plot No. .	1	2	3	4(S)	1	2	3
Md. .	211	297	276	294	215	246	316

Plots 1 . . . . . 5 Md. cake per acre.
Plots 2 . . . . . 10 „ „ „ „
Plots 3 . . . . . 15 „ „ „ „
Plots 1s, 2s, 3s. . . . . 2 „ Super in addition to cake per acre.
Plots 4 (S) . . . . 4 „ $NaNO_3$ *plus* 2 md. super per acre.

The following statement shows the average yield of stripped cane per acre from each kind of manure applied :—

TABLE X.

Manures	5 md. cake	5 md. cake and 2 md. super	10 md. cake	10 md. cake and 2 md. super	15 md. cake	15 md. cake and 2 md. super	4 md. $NaNO_3$ and 2 md. super
Yield per acre in md.	418·30	490·32	495·30	528·20	589·12	564·4	529·4

1. It will be seen that the addition of 2 md. super to cake has given 72 md. and 95 md. cane more per acre in the case of 5 md. cake and 10 md. cake per acre respectively.
2. 15 md. cake plots have given higher yields than 15 md. cake *plus* 2 md. super and the outturn from 15 md. cake is the highest of the whole.
3. 4 md. $NaNO_3$ and 2 md. super gave just equal outturn to 10 md. cake *plus* 2 md. super.

(3) *Varietal tests.* The following varieties were planted in February 1927 for field scale trials. The yield of stripped cane per acre is as follows :—

	Md. per acre.
Co. 248	548
Co. 270	588
Co. 273	254
Co. 275	473
Co. 280	183
Co. 281	185
Co. 282	221
Co. 287	450
Co. 290	269

The first two varieties Co. 248 and Co. 270 showed a better stand and the same remarks as in last year's report apply to this season also.

Co. 273 and Co. 275 have been discarded as unsuitable.

Co. 280, Co. 281 and Co. 282 were on the poor side from the very beginning. They have, however, been planted again for further tests.

Co. 287 and Co. 290 are tonnage canes, but they are soft canes. Their outturn was reduced by lodging and jackal attack. These have been again planted this year both in October and February for further observations.

The four varieties Co. 205, Co. 210, Co. 213 and Co. 214, which are now standard varieties, gave the following yields from the February planted canes :—

	Md. Stripped cane per acre
Co. 205	567
Co. 210	678
Co. 213	605

(4) *Propagation of new varieties in nursery.* Fourteen new varieties received from Coimbatore in February 1926 and multiplied in the Pusa Kitchen Garden under irrigation were planted in the New Area nursery plot in February 1927. These were not this time irrigated. Along with these, thirteen varieties of seedling canes supplied by the Imperial

Economic Botanist, Pusa, were also planted in the nursery. Thirteen varieties out of the whole lot of 27 have been planted this year in Brickfield No. 2 on a field-scale under ordinary conditions and these are :–

B. S. 3, B. S. 4, B. S. 5, B. S. 11, Co. 294, Co. 296, Co. 297, Co. 298, Co. 299, Co. 300, Co. 301, Co. 302 and Co. 303.

They were found promising both in growth and analysis. The remaining ones, which did not give sufficient material for planting outside the nursery and were not considered promising, have been kept in the nursery. These are :—

B. S. 1, B. S. 2, B. S. 6, B. S. 7, B. S. 8, B. S 9, B. S. 10, B. S. 12, B. S. 13, Co. 295, Co. 304, Co. 305, Co. 306 and BH10 (12).

All nursery canes were chemically analysed seven times from October 1927 to February 1928. The results of the analyses in December 1927 showed four canes with over 19 per cent. sucrose in the juice.

Two Coimbatore varieties 307 and 308 and four P. O. J. seedlings (P. O. J. 2725, 2714, 2727 and 2696) were received from Coimbatore and one Co. 223 from Lyallpur in February 1927 and were planted in the New Area nursery. P. O. J. 2725 died altogether and the remaining ones survied to give a few setts only and have been planted again in the nursery and irrigation has been applied this year.

The Government Sugarcane Expert, Coimbatore, supplied six seedlings, *viz.*, Co. 310, Co. 311, Co. 312, Co. 313, Co. 315 and Co. 316 and the Imperial Economic Botanist, Pusa, supplied two varieties B. S. 14 and 15 in February 1928. These have been planted in the nursery and will be multiplied by short planting.

(5) *Gur making.* Under orders from the Agricultural Adviser to the Government of India, it was proposed to crush all the available cane to make *gur* in order to see if it pays as compared to selling the cane to the nearest sugar mill.

The Poona multiple type of furnace was consequently constructed and two power crushing mills (Honololu 4-roller and a " Gem " 3-roller) were erected. Crushing was started on the 1st December, 1927. The mills were driven by motor tractors and when used singly gave 55 to 58 per cent. extraction. It was, therefore, decided to crush the cane first in one mill and then pass the megass through the other ; in this case an extraction up to 66 per cent. was obtained, varying with different varieties of cane. The working was restricted to the day-time only. The mills were worked from 7 a.m. to 12 noon in which time they crushed on an average 100 md. cane. The juice obtained was boiled in four pans and boiling each day was finished at sunset. Each pan took 2 hours and 46 minutes for boiling on an average of 48 boilings.

From the 1st December 1927 to the 17th December 1927, 1,488 md. of cane were crushed and 120 md. 23 sr. 8 ch. *gur* was obtained, that is, 8·1 per cent.

The cost of manufacture was as follows :—

	Rs.	A.	P.
Kerosene oil and other stores used	148	11	6
Labour	111	10	6
Wages of mistry	19	4	0
	279	10	0

This works out at Rs. 2-5-1 per maund of *gur* manufactured. Therefore, the cost of making 8·1 md. *gur* is Rs. 18-12-5.

	Rs.	A.	P.
Value of 8·1 md. *gur* at Rs. 5 which was the market rate at that time is	40	8	0
	18	12	5
Net value of 8·1 md. *gur*, or 100 md. cane, after deducting the cost of manufacture	21	11	7
Value of 100 md. cane at As. 4 p. 8 per md. if sold to mill .	29	2	8
	21	11	7
Net loss therefore per 100 md. cane if made into *gur* . .	7	7	1

The wages of the " gulwa " obtained from Poona at Rs. 2-8 per day and depreciation and interest on plant and other miscellaneous expenses on dead-stock materials have not been taken into account. As the market price of *gur* was low, *gur* making was not found to pay and was consequently discontinued. Cane was, as usual, sent to the Samastipur Mill. The price of *gur* fell down to Rs. 4 per maund in April 1928 and it had to be sold at that price to save further loss in storing.

Gur obtained from Co. 205, Co. 210, Co. 213 and Co. 287 was of bright colour, but it was soft. It melted in the stores later on.

The *gur* of Co. 214, Co. 248, Co. 270, Co. 280 and Co. 290 was hard and remained hard till sold in April but was of dark colour.

(6) *Investigations in mosaic disease and insect pests.*—The Imperial Mycologist and the Imperial Entomologist are engaged in these investigations, especially with regard to mosaic which is receiving considerable attention from the Mycological Section. Full details will be found in the reports of the above Sections.

X. Reclamation of Waste Land.

The levelling and reclamation of waste flooded land has now been completed. This, although flooded during the rains, is cultivated under irrigation during the cold and hot weather. It is cropped with berseem followed by maize, and grazed by the pedigree milk herd. The result of this treatment is that what was formerly rough sandy jungle is now

the richest part of the Farm. Part of it has been tested by the Bacteriological Section and shows nearly twice the nitrogen content as compared with the best Farm land.

Berseem sowing started on the 3rd October, 1927, and cattle were grazing on it on the 22nd November, 1927. It was available till the end of April 1928 when early maize was ready.

XI. Implements and Machinery.

The following tables give the results of Fowler's double system Steam Ploughing Tackle and the results of the tractors used on the Farm. The tractor table is very significant and shows the "life-history" of these tractors.

TABLE XI.

Showing the cost and output of working the Fowler's Steam Ploughing Tackle during 1927-28.

Labour	Fuel	Oil	Renewals and stores	Total working cost	PLOUGHING			GRUBBING			DISC HARROWING			ROLLING			Total working days
					Total work	Work per day	Cost per acre	Total work	Work per day	Cost per acre	Total work	Work per day	Cost per acre	Total work	Work per day	Cost per acre	
Rs	Rs.	Rs.	Rs.	Rs.	Acres.	Acres	Rs.	Acres	Acres	Rs.	Acres	Acres	Rs.	Acres	Acres	Rs.	
1,383	1,383	226	2,218	5,210	442	9	5·5	209	21·8	2·4	580	14·9	3·5	136	29·5	1·8	100
*1,186	1,652	440	1,820	5,097	357	8	6	462	22	2	544	18	3	349	23	2	116

*Average of previous 10 yrs. as given in last year's report.

TABLE XII.

Showing the consumption of fuel, lubricating oil, etc., in different motor tractors used on the Pusa Farm from their date of purchase to the end of 1927.

Name of tractor	Kind of work done	Total No. of hours worked	KEROSENE OIL		PETROL		LUBRICATING OIL		Grease Total	Waste Total	Total cost of spare parts
			Total gallons	Per hour gallons	Total gallons	Per hour gallons	Total gallons	Per hour gallons			
									lb.	lb.	Rs.
Fordson 1919-27 . .	Cultivation . .	1,726	2,851	1·6	87	0·05	375	·21	70	40	2,058
	Belt pulley . .	503	417	0·8	60	0·12	68	·13	10	8	..
Austin 1920-27 . .	Cultivation . .	2,207	2,876	1·3	130	0·06	376	·17	82	50	2,476
	Belt pulley . .	816	585	0·7	85	0·10	76	·09	39	20	..
Cletrac 1921-27 . . .	Cultivation . .	1,246	2,008	1·6	113	0·09	336	·27	289	44	4,039

TABLE XII.

Showing the summary of work done by the different tractors used on the Pusa Farm from their date of purchase to the end of 1927.

Name of tractor	PLOUGHING			DISC HARROWING			GRUBBING			ROLLING			REAPING			DRILLING			PLANKING		
	Hours	Acre	Acres per hour	Hours	Acres	Acres per hour	Hours	Acres	Acres per hour	Hours	Acres	Acres per hour	Hours	Acres	Acres per hour	Hours	Acres	Acres per hour	Hours	Acres	Acres per hour
Fordson .	430	226	0·52	692	894	1·29	412	635	1·54	107	150	1·40	83	84	1·01	2	2	1	..	..	..
Austin .	251	116	0·46	1,008	1,296	1·28	752	1,065	1·41	63	92	1·47	108	102	·94	3	3	1	22	53	2·4
Cletrac .	169	105	0·62	536	817	1·52	385	569	1·48	113	165	1·46	41	51	1·24	..	..	..	2	4	2·0

PLATE I.

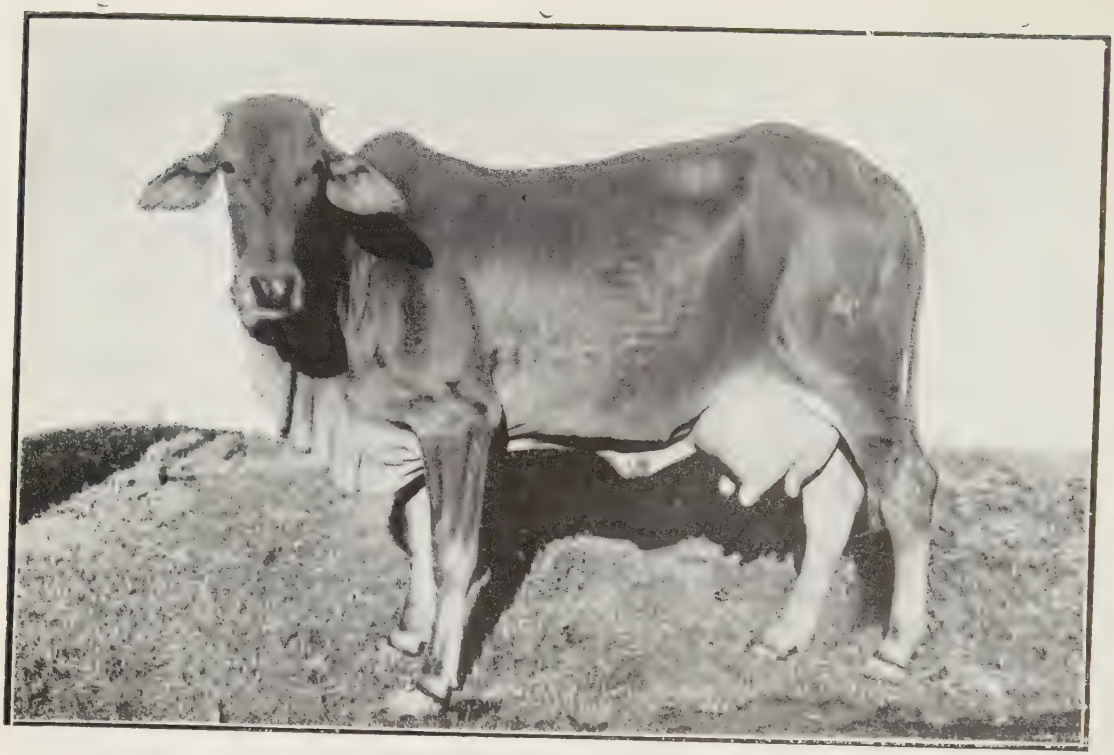

Fig. 1. Sahiwal heifer No. 451 (*Chapla*) in milk.

Fig. 2. Cows on Berseem.

XII. Pedigree Dairy Herd.

The strength of the dairy herd at the end of the year stood at 354 animals. The condition of the cattle throughout the period was exceedingly good and they had green fodder crops to graze upon for the full 12 months.

(*a*) *Pure Sahiwal herd.* Work with the pure Montgomery or Sahiwal herd was continued as usual. The standard for qualification in this herd is a lactation of over 4,000 lb. in ten months. Of the Sahiwal cows completing a lactation during the year 1927-28, the following are the best :—

Table XIV.

Pure Sahiwal cows.

Serial No.	Name and No. of cow	Date of birth	No. of calving	Quantity of milk given	
				lb.	days
1	Mirja 396	27-12-19	4	6,360	306
2	Hanumati 399 . . .	10-2-20	5	6,190	305
3	Mania 388	4-7-19	4	5,914	304
4	Munni 454	2-9-22	2	5,106	303
5	Mina 338	17-11-17	6	4,879	306
6	Mundri 389	11-8-19	4	4,832	239

(*b*) *Cross-bred herd.* Work with the cross-bred herd originally produced by crossing pedigree Ayrshire bulls and rejected Montgomery cows was continued as in the previous year. The following are the best results.

TABLE XV.

Half-bred Ayrshire-Montgomery cows.

Serial No.	Name and No. of cow	Date of birth	No. of calving	Quantity of milk given	
				lb.	days
1	Lily 103	10-9-21	3	9,181	303
2	Kitty 10	22-5-16	9	8,906	306
3	Laura 98	9-8-21	3	8,419	304
4	Nelly 13	27-10-16	8	8,102	297
5	Letitia 125	21-7-22	3	7,677	305
6	Maudie 40	16-6-18	6	7,670	304

TABLE XVI.

Miscellaneous cross cows.

Serial No.	Name and No. of cow	Date of birth	Breed	No. of calving	Quantity of milk given	
					lb.	days
1	Pearl 130 .	4-12-22	Half Holstein-Sahiwal.	2	9,611	304
2	Philis 131 .	10-12-22	Half Holstein-Sahiwal.	3	8,301	304
3	Mercy 74 .	31-3-20	Double cross Ayrshire Sahiwal.	4	6,124	306
4	Olga 38 .	16-1-18	¾ Ayrshire and ¼ Sahiwal.	5	5,385	298
5	Rhoda 128 .	14-10-22	¼ Ayrshire and ¾ Sahiwal.	2	4,803	304
6	Flo 32 .	22-10-17	¾ Ayrshire and ¼ Sahiwal.	6	4,802	304

(c) *Yield of milk.* The following table gives the milk yield for the year under report.

TABLE XVII.

Statement of milk yield in lb. for 1927-28.

Months	MILK YIELD OF					AVERAGE YIELD PER DAY AND PER COW PER DAY									
	CROSS-BRED COWS			Pure Montgomery cows	Total yield of cross-bred and Montgomery cows	CROSS-BRED COWS						MONTGOMERY COWS		TOTAL OF CROSS-BRED AND MONTGOMERY COWS	
						½ *Ayrshire cows*		*Miscellaneous crosses*		*Total of cross-bred*					
	½ Ayrshire cows	Miscellaneous crosses	Total of cross-bred cows			Average per day	Average per cow per day	Average per day	Average per cow per day	Average per day	Average per cow per day	Average per day	Average per cow per day	Average per day	Average per cow per day
July 1927 .	16,550	5,739	22,239	15,313	37,602	534	19·8	185	15·4	719	18·4	494	11·8	1,213	15·0
August ,, .	15,738	4,492	20,230	15,953	36,183	508	19·5	145	13·2	653	17·6	515	11·7	1,167	14·4
September ,, .	12,779	4,001	16,780	17,495	34,275	426	20·3	133	12·0	559	17·4	583	12·7	1,142	14·6
October ,, .	14,585	4,239	18,874	16,578	35,452	471	21·4	138	13·8	609	19·0	535	11·9	1,144	14·9
November ,, .	15,260	5,701	20,961	13,069	34,030	509	21·2	190	19·0	699	20·6	435	10·9	1,134	15·3
December ,, .	16,677	8,980	25,657	13,367	39,024	538	21·5	290	20·7	828	21·2	431	11·0	1,259	16·1
January 1928 .	17,448	9,367	26,815	12,022	38,837	563	22·5	302	20·1	865	21·6	388	11·7	1,253	17·1
February ,, .	19,356	7,478	26,834	11,033	37,867	667	23·8	258	21·5	925	23·1	381	11·9	1,306	18·1
March ,, .	19,097	7,164	26,261	12,164	38,425	616	22·8	231	19·2	847	21·7	392	12·2	1,239	17·4
April ,, .	17,322	7,150	24,472	13,347	37,819	578	21·4	238	18·3	816	20·4	445	15·3	1,261	18·3
May ,, .	17,504	8,234	25,738	14,303	40,041	565	21·7	266	19·0	831	20·8	461	14·9	1,292	18·2
June ,, .	16,707	9,330	26,037	15,992	42,029	557	23·2	311	19·4	868	21·7	533	16·2	1,401	19·2
	199,023	81,925	280,948	170,636	451,584										
Average per month 1927-28	16,585	6,827	23,412	14,220	37,632	544	21·6	224	17·6	768	20·3	466	12·7	1,234	16·5
Average per month 1926-27	..	..	22,439	13,854	36,293	..	..	..	..	738	20·5	455	11·7	1,193	15·9

(*d*) *Percentage of cows in milk.* Throughout the year the average percentage of cross-bred cows in milk was 68 with a maximum of 75 in July and a minimum of 58 in September. In the Montgomery herd 51 per cent. averaged in milk throughout the year with a maximum of 55 in June and August and a minimum of 48 in December.

(*e*) *Calf rearing.* The percentage of mortality among the calves which were pail fed during the year was 9 per cent., as against 13 per cent. in the previous year and 17 per cent. in 1925-26.

(*f*) *Clean milk.* By means of careful technique in handling cows and milk before distribution, every endeavour was made to keep the bacterial count of the milk as low as possible. According to the standard adopted by the Ministry of Health in Great Britain, certified milk, which is the highest grade, must contain less than 30,000 bacilli per cubic centimetre. During 1927 Pusa milk exceeded this only for a short period in the month of July. The rest of the year showed, according to the tests conducted by the Bacteriological Section, a very low bacterial count. The milk is sold without any pasteurisation or cooling ; hence the capital involved is kept at a low figure.

(*g*) *Sale of milk.* Part of the milk is sold in Muzaffarpur city, 22 miles distant ; it is transported by a Ford lorry. It was found that the condition remained good even during the hottest weather. Part of the milk is sold from a shop in the bazaar, and since this has been done, other shops have sprung up to the resulting advantage of the milk supply of Muzaffarpur city.

XIII. General.

Sale of cattle. The following statement shows the number of cattle sold during the year 1927-28 :—

Table XVIII.

No. of cattle	Description of cattle	Price obtained	Average price per animal
		Rs.	Rs.
37	Montgomery cows	3,653	99
8	Cross-bred cows	1,721	215
1	Cross-bred bull	500	500
19	Young Montgomery bulls	3,155	166
4	Montgomery heifers	120	30
6	Cross-bred heifers	162	27
	Total .	9,311	

Financial results. The following are the cash sales for the present year and the two previous years :—

TABLE XIX

Year	Farm produce	Milk and milk produce	Sale of cattle	Total
	Rs.	Rs.	Rs.	Rs.
1927-28	9,875	26,516	9,311	45,702
1926-27	9,272	26,602	8,303	44,171
1925-26	1,534	29,415	11,217	42,166

XIV. PROGRAMME OF WORK FOR 1928-29.

1. (*a*) Practical treatment of a pedigree dairy herd of Indian cattle and a pedigree dairy herd of Montgomery-Ayrshire cattle.

(*b*) Continuance of experiments with regard to fixing a type of Montgomery-Ayrshire most suitable to Indian conditions.

2. Practical treatment of a 1,200-acre mixed farm with particular attention to profitable modern machinery and the financial results of the work.

The bulk of the produce of the Pusa Farm is used for the maintenance of the dairy herd. The rotation adopted aims at the upkeep of the fertility of the land along with supply of concentrated food and long fodder and a constant supply of green fodder throughout the year. Included in the above is the study on a practical scale of :—

(*a*) Rotations.

(*b*) Crops for fodder, seed and silage.

(*c*) Implements and machinery.

(*d*) Technique of cultural operations.

3. Continuation of collection of data and results regarding the cost and capabilities of the steam ploughing tackle on estates of this size.

4. Experiments with various types of motor tractors and ploughs for collection of data and working costs and for determination of most suitable types of tractors and implements for India. Also collaboration with manufacturers regarding the manufacturing and introduction of improvements in standard types to suit Indian conditions.

5. Experimental work at Pusa—

(*a*) Rotational experiments,

(*b*) Trial of new varieties of crops, especially leguminous fodder crops.

(*c*) Manurial experiments, especially seasonal and quantitative tests with phosphates.

(*d*) Trial of sugarcane varieties suitable for growth without irrigation, along with the Sugar Bureau.

6. Demonstrations, exhibitions and sales of surplus dairy stock, etc., will be held from time to time as occasion offers.

7. *Touring and advisory.* Visits will be paid to provincial agricultural centres.

REPORT OF THE IMPERIAL DAIRY EXPERT.

(William Smith.)

I. Introduction.

I was in charge of the work up to 17th May, 1928, when on proceeding on leave I handed over to Mr. Kothavala.

In July 1927 His Excellency the Viceroy visited the Imperial Institute of Dairying and the laboratories and cattle sheds of the Physiological Chemist to Government at Bangalore. His Excellency's continued interest in Indian agriculture and the welfare of the Indian agriculturist has stimulated progress in the development of the dairy-cattle breeding industry in the country, so much so, that in the year under review the demand made on this office for information and advice on all matters connected with dairying and cattle-breeding has exceeded those of any previous year; not only so, but the demand from the cattle-breeding departments of local Governments and Indian States in all parts of the country during the past year for the available dual purpose pure Indian bulls bred at Karnal and Bangalore farms has far exceeded the supply available, showing that those responsible for the cattle-breeding policy throughout this Empire are alive to the fact that the cattle of India in the future must be bred to produce efficient milkers and draught cattle from the same stock. The great mass of the people of India will not tolerate the killing of cattle of any age or class and India must therefore see that only efficient milkers and workers are brought into the world. The breeding results so far obtained at the Karnal farm clearly endorse the teaching of this section since its inception—that the best milking cow of the proper type produces the best working male and the inferior milk yielding cow of the same type produces the inferior working bullock, the sires being equal.

The continual and ever increasing demand for technical advice and assistance on matters concerning the treatment and transport of fresh milk and butter, the manufacture of milk products such as casein and the casein products, condensed milk, *ghee*, dried milk and the storage of dairy produce under tropical conditions emphasizes the necessity for carefully organized research work along these lines. The Creamery at Anand is particularly suited for this class of work and the need for a scientific staff of trained chemists and bacteriologists there to carry on this work is great. The greatest fillip which this country can give to the cattle-breeding industry is the organization, preferably on co-opera-

tive lines, of the *ghee* and milk selling industry, so that the producer of milk could obtain the real world value of his produce and thereby realize the economic value of the good milking cow as a profit-earner. It is a significant fact not nearly well enough emphasized in India that in every country in the world which has developed its dairy cattle the organization of the marketing of milk and the manufacture of milk products preceded any improvement in the quality of its milch cattle. The cow-owner in India cannot be expected to trouble himself about getting better milk-yielding cattle so long as he is forced to sell *ghee* produced by a wasteful and obsolete method at twelve annas per pound when the world value of butter fat, which after all is just pure *ghee*, is 250 per cent. above this figure. India is crying out for accurate knowledge on all matters concerning the most vital part of her agricultural policy—the cattle problem, and the Indian cattle problem is the dairy problem. India will not kill her cows once they are born and at no part of their history is their flesh required for food in India, therefore all cows if they are to be profitable must be milch cows. This country cannot afford to feed a cow merely to act as the dam of future generations of draught cattle. Every cow must be a profitable milk yielder herself as well as the mother of the new generation of milk givers and field bullocks. The dairy problems of India are her own peculiar problems and they will only be solved by original research, experiment and investigation in India. "The harvest truly is plenty but the labourers are few."

Central Bureau of Animal Husbandry. Pending the report of the Royal Commission on Agriculture, the question of the development of the Central Cattle Bureau has been to some extent held in abeyance, but throughout the year the bureau has endeavoured to keep buyers and sellers of the highest class of pure breeding stock in touch with each other and to encourage the formation of herds of pure types of cattle by private owners as far as possible.

II. Training.

The second batch of students studying for the Indian Dairy Diploma finished their term in December. Twenty-one students sat for examination and 18 passed, two with honours. Students taking the first three places were given gold, silver and bronze medals very kindly donated by the Indian General Trading Co., Ltd., of Bombay. In addition, ten students presented themselves for the examination for this Diploma at the Allahabad Agricultural Institute, Allahabad ; 8 of them passed.

A new class for the Indian Dairy Diploma was commenced at the Karnal Farm in November 1927 for which 27 students have been enrolled. In connection with this class some 500 enquiries for informa-

tion were received from all over India and Burma, and the 27 students now enrolled were selected from 46 actual applications received. The new students include men from almost every caste and community in India and have been drawn from the following provinces : Bombay, Madras, United Provinces, Bihar and Orissa, Bengal, Mysore State, Kashmir State and Kapurthala State.

Six students for varying periods of training from Ootacamund, Bangalore, Agra, Muttra, Karachi and Gauhati and ten Dairy Diploma students of the Allahabad Agricultural Institute received technical instruction during the year at the Bangalore and Karnal Farms and the Government Creamery at Anand.

Four post-graduate students and one post-diploma student completed their course of training at the farms and the creamery under my charge during the year, and four post-graduate students joined for training in January 1928. In addition, one research scholar deputed by the Punjab Agricultural Department joined at the Karnal Farm in September 1927.

Mr. F. J. Warth, Physiological Chemist, and his staff continued their assistance in the training of the students and the examination of feeding stuffs for all the farms. I acknowledge the ready help and valuable advice so freely given by Mr. Warth at all times.

III. Work done for Local Governments, Indian States, Municipalities, and advice given to the General Public in India, also to persons or Governments outside of India.

Bombay. At the request of the Livestock Expert to the Government of Bombay, I visited Poona in September 1927 and there addressed a public meeting on the subject of cattle-breeding, which was presided over by His Excellency the Governor of Bombay.

The Royal Dairy Farm, Bandra (Bombay), was supplied with detailed information regarding feeding and rearing of Scindi cows in the suburbs of Bombay and the milk-yielding capacity of this breed. At the request of the Infants Public Milk Supply Co., Ltd., Bombay, I selected for them in Karachi 6 Scindi cows. The Bombay Humanitarian League was supplied with information regarding the working of the Bangalore Dairy Institute in order to enable this society to prepare a scheme for the breeding of cattle, and Mr. M. K. Gandhi was supplied with copies of my notes on the working of Pinjrapoles and on methods of cattle improvement in villages. These notes he published in the issues of *Young India,* dated 14th July and 4th August, 1927. Mr. Kothavala visited Ahmedabad in January 1928 to inspect the dairy of the Satyagraha Ashram and to select a site for a model dairy farm. He also selected a bull for this dairy from the Baroda Palace

Dairy herd. Messrs. Polson Manufacturing Company were furnished with information from time to time on dairying matters. Messrs. Pasturelands, Ltd., Bombay, were supplied with information regarding the establishment of a *ghee* factory in the Punjab, and at the request of the Managing Director of this concern I visited Palgarh to inspect the dairy farm there, and as a result of this inspection I submitted detailed recommendations with plans for modernising the dairy. I also visited Rohtak to select a site for the proposed *ghee* factory of this company.

At the request of the Secretary, Karachi Corporation, I visited Karachi for the purpose of inspecting their existing dairy with a view to preparing a scheme for an enlarged Municipal Dairy in Karachi, and, later on, supplied the Corporation with a detailed scheme with necessary building plans, etc. Whilst at Karachi I visited the farms and the town depôt of the Karachi Pinjrapole in company with the Livestock Expert of the Government of Bombay, and addressed a meeting of the Managing Committee of this society regarding the better working of this organization. At their request, I procured the services of a qualified dairy manager for their Pinjrapole.

Hyderabad State. At the request of the Director General of Industries and Agriculture, Hyderabad, I visited Hyderabad in September 1927, and as a result of this visit I furnished this officer with a detailed scheme with dairy building plans and machinery specifications for the inauguration of cattle-breeding farms in this State. The Director General of Agriculture, Hyderabad State, discussed with the writer at Bangalore the working details of the scheme in the last week of April 1928. On my recommendation the State authorities have agreed to appoint Mr. Rama Rao, G.B.V.C., an employee of this State who obtained the Indian Dairy Diploma from the Bangalore Institute in December 1927, as manager of the proposed cattle-breeding farm. The Vice-President, Co-operative Credit Societies, Ltd., Hyderabad State, was advised regarding the establishment of a small dairy farm near Hyderabad for the supply of milk to the city with a capital of Rs. 10,000. The Superintendent, Government Agricultural Farm, Mahbubnagar, was advised regarding silage-making and silo pits suitable for his district. The Director of Agriculture, Hyderabad State, was given the loan of 70 lantern slides depicting the methods of milk production and handling in India to illustrate his lecture delivered at Hyderabad on 13th April 1928. The proprietor of the Maksud Dairy, Hyderabad, was supplied with particulars of Ayrshire bulls available for sale with the Kalimpong Colonial Orphan Homes.

Baroda State. The Director of Agriculture, Baroda State, was in correspondence with this office throughout the year regarding dairying and cattle-breeding matters and was supplied with all possible informa-

tion. He was also supplied with new store account forms in use at the farms under my control, and a sample of Dal Karai with a note of its analysis.

In addition to the foregoing, specific advice and information on dairying and cattle-breeding matters was supplied to firms, public bodies and individuals at Bombay, Malad, Surat, Navapur, Poona, Karachi, Lonavala, Sabarmati and Amreli (Kathiawar).

Bengal. The Director of Agriculture was supplied with information regarding cinema vans for demonstration purposes. The Assistant Director of Agriculture, Bengal, was advised as to the quantity of concentrated ration to be fed to average milch cows. The Livestock Expert to the Government of Bengal was advised from time to time regarding dairying and cattle-breeding matters and was also supplied with a number of photographs of typical animals for making lantern slides. Col. A. J. Stewart, I.M.S., of the School of Tropical Medicine, Calcutta, was advised regarding dairy exhibits for the Health and Baby Week held in February at Calcutta, and he was given the loan of dairy cinema films for use during the Baby Week. He was also provided with samples of sterilized milk from the Karnal Farm, and casein, butter and *ghee* from the Anand Creamery, for exhibition purposes.

At the request of the Registrar, Co-operative Societies, Bengal, I went to Calcutta on the 12th July, 1927, to conduct His Excellency the Governor of Bengal over the premises of the Co-operative Milk Union and to explain the design of the buildings and the functions of the plant to him. On the 14th July, 1927, I addressed a public meeting under the auspices of the Co-operative Department in the University Institute, Calcutta, with the Mayor of Calcutta as Chairman. I again visited Calcutta early in January 1928, at the request of the Deputy Chairman, Calcutta Co-operative Milk Societies Union, and advised him regarding the general expansion of their work in connection with dairy organization. From Calcutta I visited Darjeeling at the request of the Minister in charge of Agriculture, Bengal, and the Registrar, Co-operative Credit Societies, and as a result of my visit an entirely new set of building plans and machinery specifications for the proposed dairy factory in Darjeeling were submitted. On my return from Darjeeling I conducted the Health Committee of the League of Nations over the dairy factory of the Calcutta Co-operative Milk Societies Union, and explained to them the general system of the working of this factory. Specifications with cost of working a small village pasteurising plant were supplied to the Calcutta Co-operative Milk Societies Union and also designs of bottle discs.

The Secretary of Dairy Scheme Committee of the Calcutta Pinjrapole Society has approached this office for advice in connection with

the establishment of a dairy farm for supply of milk to Calcutta and arrangements are being made to inspect the lands owned by this society at an early date to enable this office to draw up a complete scheme for the working of the proposed dairy farm.

In addition to the foregoing, specific advice and information on dairying and cattle-breeding matters was supplied to firms, public bodies and individuals at Dayarampur (Rajshahi), Calcutta, and Hathipotha (E. Duars).

Madras. The Deputy Director of Agriculture, Livestock, Madras, was in correspondence with this office regarding dairying and cattle-breeding matters, and at his request I selected for the Hosur Cattle Farm 18 Scindi cows at Karachi. At his request I visited the Agricultural College Dairy at Coimbatore and as a result of this visit submitted plans and specifications for the rebuilding and re-equipment of that dairy in order to render it more suitable for educational purposes. This officer was also provided with a drawing of the cow stanchions and partition in use at the Bangalore Institute.

The Superintendent, Alipuram Jail, was advised as to the possibility of establishing a jail dairy in Bellary. He was also provided with information regarding the feeding of dairy cattle and was supplied with a plan for a model dairy farm. At the request of this officer I selected and branded 4 Scindi cows for the Jail Dairy at Karachi.

Mysore. At the request of the Superintendent, Oorgaum Gold Mining Co., I visited the Kolar Gold Field Dairy in March 1928 and inspected the proposed new dairy collecting stations in the vicinity of that district with a view to advising the Kolar Gold Field authorities as to the suitability of the proposed collecting stations and the lay-out and erection of the new pasteurising and refrigerating plants obtained from England.

The District Economic Superintendent, Kadur District, was advised from time to time regarding dairying problems connected with his economical development work. The Director of Agriculture, Mysore, was advised in connection with the dairy machinery to be erected at the Rayankere Dairy. He was also given the loan of cinema films depicting modern methods of cattle-rearing and dairying for exhibition during the *Dasara* festivities at Mysore.

At the request of Lady Todhunter, Mysore, she was furnished with a plan of a cow shed suitable for housing 8 cows, also a standard plan of a model milking shed. She was also advised on various matters concerning cattle-breeding.

Bangalore C. & M. Station. At the request of the Sectretary, Society for the Prevention of Cruelty to Animals, Bangalore, Mr. Kothavala acted as a judge of the animals exhibited at the Animal Show. A butter-making demonstration was given at the show by the Banga-

lore Institute, but no animals were exhibited on account of prevalence of anthrax in the district. The Veterinary Superintendent, Tasker Veterinary Hospital, Bangalore, was advised about maintaining stud bulls for stud purposes at the hospital.

Coorg. Mr A. B. Chengappa of Veerarajendrapet was supplied with three heifers and 2 bulls from the Bangalore Dairy Institute.

In addition to the foregoing, specific advice and information on dairying and cattle-breeding matters was supplied to public bodies and individuals at Madras, Metur, Trichinopoly, Trichur, Davangeri and Port Novo.

Punjab. The Deputy Secretary to the Government of Punjab, P. W. D., was supplied with copies of standard plans of sheds for dairy cattle. The Director of Agriculture, Punjab, was supplied with information regarding co-operative dairying in Bengal and he was advised as to the necessity of pasteurising village milk. The Chief Superintendent, C. V. D., Lahore, was given the loan of 4 dairy cinema films, 176 lantern slides, a number of milk posters and photographs for use on the demonstration train run by the Government of Punjab. He was also supplied with samples of sterilized milk in bottles and cans from Karnal farm, Cheddar cheese from Bangalore, and casein, *ghee* and tinned butter from the Anand Creamery, for exhibition on this train. The Principal, Agricultural College, Lyallpur, was given the loan of cinema films dealing with modern dairying for exhibition to the members of the Chenab Colony Agricultural Association and to the students of the Agricultural College, Punjab.

Syed Mohamed Hussein, M.L.C., of Shergarh, was supplied with a blue print of our standard dairy plan showing relation of one building to another in the lay-out of a modern dairy farm. Later on at his request I provided him with detailed plans and sections of the dairy buildings and also advised him regarding roofing of these buildings.

In addition to the foregoing, specific information on dairying and cattle-breeding matters was supplied to public bodies, firms and individuals at Delhi, Karnal, Amritsar and Gujrat.

Patiala State. The Director of Agriculture was advised as to the feeding value of green *shaftal* to milch cattle.

United Provinces. The Deputy Director of Agriculture in charge of Cattle-Breeding, United Provinces, was furnished with information regarding insulated railway vans. The Deputy Director of Agriculture, Bundelkhand Circle, was supplied with plans showing the lay-out of dairy buildings for 75 cows with a note of the estimated cost of construction of the same. He was also advised as to the best breed of milch cattle suitable for his district. The Inspector of Agriculture and Cattle Breeding, Etawah, was given the loan of cinema films dealing with modern dairying and cattle-breeding, for exhibition at the Dairy and

Cattle Show held at Etawah in December 1927. At the request of the Officer commanding His Excellency the Viceroy's Body Guard, Dehra Dun, Mr. F. E. Traynor visited their dairy in August 1927 and again in April 1928, and advised this officer in regard to dairying and cattle-breeding matters.

The Secretary, Gopal Mandal, Gorakhpur, was advised on cattle-breeding and was supplied with the plan of a standard cow shed.

In addition to the foregoing, specific advice and information on dairying and cattle-breeding was supplied to public bodies and individuals at Lucknow, Bareilly, Buldandshahr, Allahabad, Jhansi and Ramnagar (Naini Tal).

Central Provinces. At the request of the Principal, Agricultural College, Nagpur, I selected and branded 5 Murrah buffaloes for him at Karachi. At the request of the Deputy Director of Agriculture, Animal Husbandry, Nagpur, arrangements have been made for supplying him with 3 pedigreed bulls and three bull-calves from the Karnal Farm.

Mr. Bapuji P. Masani of Paraswaraghal and Mr. P. P. Ambullesar of Khamgaon were supplied with specific information and advice on dairying and cattle-breeding matters.

Indore State. Mr. S. K. Bhandari of Indore was supplied with detailed information in connection with his starting a dairy with a capital of Rs. 20,000 for supply of milk to Indore city.

Dhar State. A scheme for the establishment of a small dairy farm in Dhar submitted by Mr. G. S. Nadkar, I.D.D., was criticised and he was supplied with helpful information regarding the improvement of the Nimari and Malvi breeds.

Jaipur State. At the request of the State authorities I visited Jaipur towards the end of January 1928 and as a result of this visit a note embodying my proposals for the improvement of cattle in this State was submitted and which is being acted upon.

Kishangarh State. From Jaipur I visited Kishangarh and after inspection of cattle in selected villages a report making proposals for the betterment of the cattle of that State was submitted.

Ajmer. Mr. K. Ganpati Singh of Kharwa and the Registrar, Co-operative Societies, Ajmer-Marwar, were supplied with specific information on dairying and cattle-breeding matters.

Bihar and Orissa. At the request of the Director, Civil Veterinary Department, Patna, I visited Karachi in October 1927 to assist him in the selection of cattle to form the foundation herd of the Veterinary College Dairy, and I visited Patna in January 1928 in order to inspect the dairy buildings in the course of construction. I again visited Karachi in February 1928 to select cattle for the Veterinary College Dairy, Patna.

and two pedigree bulls were also supplied from the Karnal Farm for this dairy.

The Deputy Director of Agriculture, Chota-Nagpur Range, was advised as to the best sterilizing outfit for sterilizing utensils. He was also advised as to the quantity of salt to be fed to dairy cattle.

In addition to the foregoing, specific advice and information on dairying and cattle-breeding matters was supplied to Mr. Niranjan Parija of the Bidyadharpur Agricultural Farm (Cuttack), the Manager, Pursa Sugar Factory (Lauriya) and Mr. Shyamakant, Zamindar of Hasua (Gaya). Information was also furnished to firms, individuals and public bodies at Kanti, Begusarai, Purulia and Tilothoo (Shahbad).

Assam. I visited Shillong in January 1928 and there inspected the Upper Shillong Government Farm, and advised the Government of Assam as to its future working. At the request of the Director of Agriculture, I selected for him at Karachi 22 cows and 2 bulls of the Scindi breed and supplied him with 4 Thar-Parkar bulls from the Karnal Farm. I also supplied him with publications issued by this department. At the request of Nawab A. Aziz, I visited his Motijan Estate at Titabar (Jorhat) from Shillong and advised him on the spot regarding the establishment of a dairy farm. Whilst at Jorhat I had an interview with the Governor of Assam and later on submitted to him a note regarding the steps to be taken concerning the improvement of the cattle of that province. The Deputy Director of Agriculture, Assam, was supplied with sample forms of the complete set of records maintained at the Bangalore Institute in regard to cattle-breeding. He was also supplied with particulars of Ayrshire bulls available for sale at Kalimpong. The Superintendent of Agriculture, Surma Valley, Sylhet, was supplied with information concerning the establishment of a dairy farm on a small scale. The Manager of the Government Farm, Khanapara (Gauhati), was supplied with particulars of books and journals necessary for reference, he was also supplied with specimen forms of account books and forms in use at the Imperial Dairy Institute at Bangalore. The Commandant, 5th Battalion, Assam Rifles, Lokra, was advised as to the best breed of cattle suitable for Assam, and at his request I selected and branded for him one Scindi bull and two cows at Karachi. The Sub-Divisional Officer, Satkhira, was advised as to the best type of bulls suitable for breeding purposes for use by the Union Boards of his district.

Advice given to Foreigners. The editor of the *Worlds' Butter Review*, Edmonton, Alberta (Canada), was supplied with information as to the methods of manufacture of *ghee* in India. The Consul General for Belgium (Calcutta) was furnished with detailed particulars of the various

Indian breeds of dairy cattle, for use of the University of Louvain. The Editor of Tillotson's Directory of Pedigree Stock-breeders was furnished with information regarding crossing of Indian cattle with foreign bulls. The Director, Science and Agriculture Department, Georgetown, Demerara, was advised as to the best breed of buffaloes suitable for his part of the world.

IV. General.

A cinematograph entertainment illustrative of dairying and cattle-breeding in other countries as compared with India was given at the Globe Theatre, Bangalore, on the 23rd and 24th August, 1927, for the benefit of the students of the Imperial Institute of Animal Husbandry and Dairying and the general public. A cinema film depicting the visit of His Excellency the Viceroy to the Imperial Cattle-Breeding Farm, Karnal, was also shown at this meeting.

The Physiological Chemist to the Government of India has been provided with facilities at the Imperial Dairy Institute, Bangalore, for carrying out experiments on the relationship between maturity and the fodder value of *juar* and on silage making.

The following articles and notes were written for publication in the *Journal of Animal Husbandry and Dairying in India* :—

(1) The Murrah buffalo, by Mr. Wm. Smith.
(2) Note on the working of *Pinjrapoles*, by Mr. Wm. Smith.
(3) Casein making in Gujarat, by Mr. Zal R. Kothavala.
(4) The Kankrej cattle, by Zal R. Kothavala.

The article on " Casein making in Gujarat " was also read at the Science Congress held at Calcutta in January 1928.

II.

(Zal R. Kothavala, B.Ag., B.Sc., N.D.D.)

I took over charge of the duties of Imperial Dairy Expert from Mr. Smith who proceeded on leave on the afternoon of 17th May, 1928.

Since taking over charge, the following advisory work was performed in addition to the administration of the Section :—

(*a*) The Director of Agriculture, Bihar and Orissa, was advised regarding the feeding of calves from birth. Copies of ration statements showing the grains and fodders fed to the cattle at the Bangalore, Wellington and Karnal Farms were also supplied.

(*b*) The Superintendent, Oorgaum Gold Mining Co., was advised to breed cattle in order to improve the cattle of his district. He was also supplied with copies of dairy regulations in force in England in order to introduce similar rules for the control of the supply of milk in their estate.

(*c*) At the request of the Municipal Commissioner, Bangalore City, the municipal members were taken round the Imperial Institute of Animal Husbandry and Dairying, Bangalore, and measures for improving the milk supply of Bangalore city were discussed with them by me on the spot.

V. Karnal, Bangalore and Wellington Farms and Anand Creamery.

1. *Karnal.* The Farm has 2,154 acres of land of which 320·4 acres are under direct cultivation, 871·8 acres are leased on *batai*, 242·5 acres are on cash rental, and 719·3 acres are for buildings and grazing areas. The chief crops grown were rice, wheat, gram, *juar* and sugarcane.

At the suggestion of the Secretary, Sugar Bureau, 8 acres of Co. 213 cane was sown, the object being to supply seed to the district. Practically the whole of this crop was sold as such. The farm supplied 600 maunds of Punjab 8-A wheat seed to the Punjab Government.

The strength of the herd at the commencement of the year was 518 and at the end 586. One hundred and forty-one calves were born, 69 cattle of all classes died of which 53 were calves under 1 year, and 43 animals were sold.

The Farm has three breeds of cattle, *viz.*, the Thar-Parkar and the Hariana, and the Murrah buffaloes. The adult herd comprises of 95 Thar-Parkars. 63 Harianas, and 19 buffaloes. Of the 95 Thar-Parkars, 65 completed a lactation period during the year : 16 gave over 3,000 lb. of milk, 13 between 2,000 and 3,000 lb., 21 between 1,000 and 2,000 lb., and 15 under 1,000 lb. Of the 63 Harianas, 62 completed a lactation period : 12 gave over 3,000 lb. of milk, 18 between 2,000 and 3,000 lb., 15 between 1,000 and 2,000 lb. and 17 under 1,000 lb. Seventeen of the 19 buffaloes completed a lactation, of which 11 gave over 3,000 lb., 2 between 2,000 and 3,000, 1 between 1,000 and 2,000 lb., and 3 under 1,000 lb. The average of the Thar-Parkar herd was 1,965 lb., of the Hariana herd 1,905 lb. and of the buffalo herd 3,278 lb. Nine stud bulls were sold at an average price of Rs. 278 ; 4 went to Assam, 2 to Patna and 3 to Bengal. Except for periodic outbreaks of black quarter the general health of the herd was good.

The following table shows the yields of 6 principal cows of the Thar-Parkar and Hariana breeds which completed their lactation period during the year :—

Animal No.	Name	Approximate age on 31st March 1928	Milk yield	Days in milk	Remarks
			lb.		
	Thar-Parkar Breed.				
119	Pomeray . .	9 years	5,313	369	Weaned. Purchased.
44	Artiste . . .	9 „	4,237	328	„ „
53	Mamre . . .	8 „	4,070	281	„ „
135	Dot . . .	8 „	3,865	284	„ „
38	Dewan . . .	9 „	3,821	286	Calf tied at heel.
182	Ada . . .	4 „	3,455	291	Weaned.
	Hariana Breed.				
110	Hope . . .	7 „	4,680½	315	Weaned.
164	Molly . . .	6 „	4,169	441	Not weaned. Purchased.
109	Wonder . .	7 „	3,944	338	Weaned.
108	Cawnpore Iris .	8 „	3,806	293	„
181	Blacky . . .	7 „	3,802	424	Not weaned. Purchased.
145	Agra Witch . .	5 „	3,642	292	Weaned.

The farm was visited by many people during the year including 4 members of the Legislative Assembly, the Minister for Local Self-Government, Punjab, Lady Hailey and the Director of Agriculture, Punjab.

The outturn of grain and fodder during the year is shown in Appendix I attached to this report.

2. *Bangalore.* The Institute is in possession of 291 acres of land. The main farm at Bangalore is of 110 acres, of which 60 acres are under

cultivation and the balance divided between buildings and grazing or exercise grounds for the cattle. In addition to this land, the Institute has taken on lease 5 acres for fodder cultivation and 5 acres and 21 gunthas adjoining the Institute for storing hay and silage and as an exercising ground for cattle.

The general monsoon crop of the home farm is *juar* of which only one cutting is obtained. Guinea grass and lucerne are grown under irrigation to the extent water is available.

At Bommanpalli, a distance of 6½ miles from the Institute, there are 50 acres of Government owned land and 33 acres of rented land. Only 12 acres of this land are under cultivation. The rest of the area is being used as grazing land for dry cattle and young stock of which generally about 100 head are kept there. The cultivated crop is *juar* which is chaffed and put into silage pits.

At Hebbal, seven miles in another direction, we have 98 acres of dry land with a cattle shed, feeding troughs, and servants' quarters.

At the commencement of the year, the adult herd consisted of 47 half-bred, 14 ¾-bred, and 48 Scindi cows, and one Jersey, 2 Ayrshire, 3 Sahiwal and 2 Scindi bulls. In addition, there were 11 Delhi buffaloes and 2 Delhi buffalo bulls. The young stock consisted of 120 cow-calves and 5 buffalo-calves of all ages.

During the year 31 Scindi cows were purchased from Karachi, and 10 Scindi young stock heifers were received from the Wellington Farm. Thirty-four animals were sold by public auction, and 61 died.

Except for minor outbreaks of foot-and-mouth and blackquarter the health of the herd on the whole was good.

The following table shows the yields of 12 principal cross-bred and Scindi cows which completed their lactation during the year :—

Serial No.	Number of cow	Date of birth	Number of calving	Quantity of milk given	Number of days in milk
				lb.	
	Cross-bred.				
1	133, Half-bred . .	18th October 1909 .	16	9,637	299
2	346A, „ . .	15th October 1921 .	3	8,149	346
3	523 „ . .	24th January 1916 .	8	7,650	333
4	372A, ¾ bred . . .	15th February 1922	3	7,286	372
5	353A, „ „	9th November 1921	3	7,111	302
6	378A, Half-bred . .	30th April 1922 .	3	6,976	323

Serial No.	Number of cow	Year of purchase and present approximate age		No. of calving since arrival	Quantity of milk given	Number of days in milk
		Year	Age			
			yrs.		lb.	
	Scindi Breed.					
1	14 . .	1923	12	3	6,844	438
2	11 . .	1923	11	3	5,685	348
3	48 . .	1925	7	2	4,314	301
4	2 . .	1923	11	4	4,151	303
5	43 . .	1925	15	2	3,955	366
6	56 . .	1925	11	2	3,650	264

During the year under review the Farm herd produced 457,448 lb. of milk which was supplemented by a purchase of 28,581 lb. 337,104 lb. were sold to British and Indian military hospitals, officers, troops and civilians at varying rates. 73,301 lb. were separated and 6,303 lb. cream and 2,590 lb. of butter were manufactured from milk produced at the Institute. 15,500 lb. of milk were turned into 1,287 lb. cheese. 59,272 lb. of separated milk were issued for feeding calves and a small quantity (2,086 lb.) was sold to the public.

The breeding policy is for all cows with imported blood to be crossed by Sahiwal Bulls, the best of the Scindi (based on the milk yield) mated to Scindi bulls and the poorer Scindis crossed by an Ayrshire bull. The progeny of the latter invariably turn out to be good milkers which is essential from the dairying point of view.

The Institute Visitors' Book was signed by 625 visitors during the year under review among whom were batches of students from various agricultural and technical schools and the following distinguished personages :—

1. His Excellency Lord Irwin, G.M.S.I., G.M.I.E., The Viceroy and Governor-General of India.
2. Mr. M. K. Gandhi.
3. Mr. Madan Mohan Malaviya, Vice-Chancellor of Benares University.
4. Sir M. Visweswaraiya, Ex-Dewan of Mysore State.
5. Sir P. S. Sivaswamy Iyer, Ex-Member of the Madras Executive Council.
6. Dr. and Mrs. Forster of the Indian Institute of Science.

The outturn of fodder from farm lands during the year will be found in Appendix II attached to this report.

3. *Wellington.* The principal feature of the working of this farm during the year under review was that the trading account of the farm showed a net profit on its working even after allowing for the cost of all experimental and research work done.

The Farm consists of 62·71 acres of land excluding 6·08 acres of building area as detailed below :—

	Acres.
Arable	35
Grazing	20·71
Forest land for fuel production	7
TOTAL	62·71

Of the above land, 3 acres were put to potatoes with a view to clearing the land, 1 acre to Rhodes grass, 1 acre to lucerne and 30 acres to maize, *juar* and oats.

At the present time, we are mainly dependent upon the grass farm for our supply of long fodder. With a view to becoming self-supporting an additional area of 52½ acres of land has been obtained from the Cantonment authorities. It is hoped to get 40 acres under cultivation within the next 2 years.

Herd. The strength of the herd maintained during the year was :—

Ayrshire cows	10
Half-bred cows Scindis	21
„ „ Sahiwal	5
„ „ Hansi	3
Three-quarter bred cows	11
Half-bred × Half-bred cows	3
„ Ayrshire cows (Jersey)	1
Pure Scindis	19
TOTAL	73

The general health of the herd throughout the year was very good. There were no outbreak of epizootic diseases during the year under review.

The breeding policy of the farm is to establish a pedigree herd of Ayrshire cattle. With this end in view, one pedigree bull and 8 pedigree heifers in calf were imported in November 1927. Since their arrival the 8 heifers have calved and produced 7 heifers and one bull-calf and all are doing well. All pure Indian cows are being sired by Ayrshire bulls and all ½ and ¾ breds are sired by Sahiwal or Scindi bulls.

The following table shows the yields of 6 principal pure Ayrshire and cross-bred cows during the year :—

TABLE

No.	Name and number of Cow.	Date of birth	No.of calving	Quantity of milk given	
				Lb.	Days
	Pure bred.				
1	Rosie No. 4 . .	9-3-21	3	9,453	309
2	Heather Blossom No. 1 .	18-4-21	4	5,091	291
3	Priestslands Lucette No. 12.	8-11-24	1	5,502/23	184
4	Priestslands Hannah No. 11.	5-5-24	1	4,888/24	165
5	Priestslands Miss Alberta No. 6.	6-4-25	1	4,747/13	232
6	Thirdpart Blossom No. 8	27-4-25	1	3,457/28	116
	Cross-bred.				
1	Dolly No. 709 . .	August 16	8	10,341	394
2	Madge No. 857 . .	3-9-17	8	9,759	502
3	Charlotte No. 225 .	3-1-24	1	9,016	547
4	Ruby No. 116 . .	25-5-17	7	7,663	477
5	Grace No. 40 . .	20-12-13	9	7,185	332
6	Victoria No. 15 . .	18-7-11	12	6,761	365

The value of dairy produce sold during the year 1927-28 was Rs. 77,186, as compared with Rs. 70,296 during 1926-27. There has been a decrease in supplies to the Military since 1925-26 of 7·5 per cent., chiefly due to the Madras District Staff having been transferred from this station to Bangalore. The value of sales of dairy produce to civilians and civil institutes during the last two years has increased by Rs. 7,455.

During the year 1927-28 we took up the supplies of Government Head Quarter Hospital, Ootacamund, and Hebron School, Coonoor.

The outturn of fodder during the year will be found in Appendix III attached to this report.

4. *Anand creamery.* Orders of Government to take over this dairy factory permanently from the Military Department were received on 31st October, 1927. Steps were immediately taken to have the spare refrigerating plant lying unused at Pusa transferred to the Anand Creamery. In erecting this plant it was necessary to rearrange and to some extent renew the existing machinery. This was completed in May and the Creamery is now in a position to manufacture and sell butter and casein on a commercial scale.

During the year the experimental work in connection with the treatment of fresh milk for transport to Bombay, the investigations into the manufacture of condensed buffalo milk, the experimental work in connection with the manufacture of casein and the work concerning the best methods of *ghee* manufacture were continued. The results of the first series of *ghee* making experiments carried out by Mr. Kothavala and the Superintendent were published in Volume I, Part II (July 1927) of the *Journal of the Central Bureau of Animal Husbandry and Dairying in India*, and they clearly show the dire necessity for this type of investigation and for vigorous propaganda work in making the knowledge yielded by these experiments known to all manufacturers of dairy produce in the country.

The combined receipts and expenditure for the Karnal, Bangalore and Wellington Farms and the Anand Creamery will be found in Appendix IV of this report.

APPENDIX I.

Outturn of grain and fodder at the Imperial Cattle Breeding Farm, Karnal, during 1927-28

Particulars	1927-28 Md. Sr. Ch.
Grain.	
Gram	2,114 7 0
Barley	381 32 8
Wheat	4,207 26 0
Ziri	2,816 2 4
Wheat and gram (mixed)	..
Mustard seed	..
Toria	155 36 8
Maize	..
Gur	274 36 8
Sugar-cane seed	3,110 15 0
Peas seed	..
Juar	..
Potatoes	..
Sanee seed	42 0 0
Sanee fibre	8 30 0
Masri	21 19 0
Fodder.	lb.
Anjan grass seed	..
Chari (green)	878,176
Chari (dry)	3,600
Feeding hay	112,840
Green grass	1,215,824
Green oats	28,029
Rice straw	281,200
Bhoosa mixed	800,560
Green maize	..
Thatching grass	..

APPENDIX II.

Showing annual outturn of fodder grown on the Farm lands during the year from 1st April 1927 to 31st March 1928 at the Imperial Institute of Animal Husbandry and Dairying, Bangalore, and dry stock farms attached to it.

Where grown	Kind of fodder	Acreage	Outturn in pounds	Total cost	Cost per 100 lb.	Remarks
Bangalore . .	Green Guinea grass . .	6·14	572,317	798 15 4	0 2 3	
	„ Lucerne. . .	1·37	120,051	613 8 5	0 8 2	
	„ Sorghum . .	60·09	847,910	2,073 11 1	0 3 11	Of this 105,750 lb. was dry fodder actual outturn being 42,300 lb.
	„ Maize . . .	1·41	7,360	60 15 9	0 13 4	In addition, there was an outturn of 420 lb. maize seed.
	„ Grass . . .	..	340,195	637 14 0	0 3 0	
	Total .	..	1,887,833	4,185 0 7	0 3 6	
Bommanpalli . .	Green Sorghum . .	..	24,960	139 3 8	0 8 11	
	Hay or Dry grass . .	..	44,777	179 11 0	0 6 5	This was all dry fodder actual outturn being 17,911 lb.
	Total .	..	69,737	318 14 8	0 7 4	
	Grand Total all Green .	..	1,957,570	4,503 15 3	0 3 8	

APPENDIX III.

Showing outturn of grain and fodder crops of the Imperial Institute of Animal Husbandry and Dairying, Wellington, during the year 1927-28.

Name of dairy	Total area of the land in possession of the Farm			1927-28							Remarks
	Arable	Grazing	Building site	Total area of land under cultivation	Total outturn in green	Total expenditure incurred on cultivation	Production rate per 100 lb.	Total fodder purchased in green	Total amount paid for purchased fodder	Average purchase rate per 100 lb.	
	Acres	Acres	Acres	Acres	lb.	Rs. A. P.	Rs. A. P.	lb.	Rs. A. P.	Rs. A. P.	
Imperial Institute of Animal Husbandry and Dairying, Wellington.	35	20·71	6·08	35	647,810			162,402	6,177 12 0	2 0 3	Purchased as dry fodder and reduced in terms of green.
	Leased land 9·07		Forest Land for Fuel 7·0	Leased land 9·07	Potatoes 72,730	5,395 2 9	0 12 0				
				44·07				61,650	385 5 0	0 10 0	Purchased as green fodder.

APPENDIX IV.

Statement showing receipts and expenditure of the Imperial Institute of Animal Husbandry and Dairying, Bangalore and Wellington, Imperial Cattle Breeding Farm, Karnal, and the Government Creamery, Anand, for the year 1927-28.

APPEN

Statement showing receipts and expenditure of the Imperial Institute of Cattle Breeding Farm, Karnal, and the Gover

Heads of receipts	Karnal	Bangalore	Wellington	Anand
	Total receipts (combined cash and book debit)	Total receipts (combined cash and book debit)	Total receipts (combined cash and book debit)	Total receipts combined (cash and book debit)
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Dairy Produce.				
On credit	9,725 3 9	75,329 15 8	54,301 10 9	33,493 6 8
On cash	2,593 11 9	5,664 12 9	7,931 6 9	1,508 7 0
On coupons	....	23,392 2 6	15,052 13 9	....
Total	12,318 15 6	1,04,386 14 11	77,285 15 3	35,001 13 8
Capital receipts.				
Livestock (dairy)	3,955 0 0	3,420 10 0	2,750 0 0	....
Livestock (draught)	35 0 0	57 0 0	....	....
Plant and machinery	12,279 8 4	1,256 0 0	....	....
Total	16,269 8 4	4,733 10 0	2,750 0 0	....
Miscellaneous receipts.				
Sale of skins	41 2 0	5 12 0	....	....
Grain and fodder	42,788 11 4	1,068 3 10	37 7 7	....
Other miscellaneous receipts.	9,562 8 4	8,677 7 8	4,519 0 0	5,502 8 4
Fees from students	2,465 0 0	2,954 0 0	....	160 0 0
Total	54,857 5 8	12,705 7 6	4,556 7 7	5,662 8 4
Grand Total	83,445 13 6	1,21,826 0 5	84,592 6 10	40,664 6 0

DIX IV.

Animal Husbandry and Dairying, Bangalore and Wellington, Imperial nment Creamery, Anand, for the year 1927-28.

Heads of expenditure	KARNAL	BANGALORE	WELLINGTON	ANAND
	Total expenditure (combined cash and book debit)	Total expenditure (combined cash and book debit)	Total expenditure (combined cash and book debit)	Total expenditure combined (cash and book debit)
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Supplies and Services.				
Purchase of creamery .	..	....	....	60,000 0 0
Lands, buildings and accessories.	6,300 0 0	11,592 11 0	3,161 3 0	909 7 0
Plant and machinery .	1,910 2 0	813 13 0	311 4 0	29,758 1 4
Purchase of dairy cattle .	4,077 6 0	11,271 0 0	17,526 0 0	....
Purchase of draught cattle	2,674 0 0	....	550 0 0	....
Electric plant lighting and fittings.	11,975 0 0	....	....	....
TOTAL OF CAPITAL ITEMS	26,936 8 0	23,677 8 0	21,548 7 0	90,667 8 4
Depreciation on buildings and machinery paid to Army Department.	....	....	....	3,290 12 6
Rent and repairs to buildings.	7,299 6 3	4,410 14 3	489 15 6	1,422 14 3
Repairs to plant, machinery and workshop.	5,148 12 6	3,185 6 9	573 13 6	1,956 2 0
Feed of dairy cattle .	27,594 7 9	42,210 7 0	21,080 13 4	....
Hire of cattle and purchase of dairy produce.	0 8 0	23,737 8 0	25,316 14 0	50,339 5 6
Ice, salt and acid . .	1,544 12 6	669 13 0	106 14 0	953 14 6
Cultivation charges .	15,092 9 0	1,685 4 6	3,926 11 9	....
Fuel, light, water and miscellaneous stores	3,118 5 3	16,451 5 10	4,310 10 3	9,626 15 6
Freight on stores . .	3,300 4 0	1,939 4 0	1,224 3 6	4,028 5 0
Medical stores . .	381 9 0	....	194 14 0	....
TOTAL OF REVENUE ITEMS	63,480 10 3	94,239 15 4	57,224 13 10	71,618 5 3
Contingencies . .	2,178 2 9	2,578 5 2	2,143 2 0	1,414 0 0
Establishments . .	30,925 0 5	33,377 2 0	18,701 13 0	11,385 1 0
Allowances . . .	985 8 0	2,286 7 0	577 13 0	739 13 0
TOTAL .	34,088 11 2	38,241 14 2	21,422 12 0	13,538 14 0
GRAND TOTAL .	1,24,505 13 5	1,56,159 5 6	1,00,196 0 10	1,75,824 11 7

REPORT OF THE PHYSIOLOGICAL CHEMIST.

(A. Viswanatha Iyer, B.A.)

I. Charge and Staff.

Charge. Mr. Warth held charge of the Section till the 6th March, 1928, on which date he proceeded on leave for eight months and Mr. A. Viswanatha Iyer assumed charge of the Section.

Staff. During the year the Section was strengthened by the appointment of one Laboratory Assistant and one Fieldman.

II. Laboratory Work.

The following is a list of the analyses completed during the year :—

Complete analyses :—		
Fodders	119	
Faeces	160	
	—	279
Dry matter in faeces, urine, silage, grasses, etc.		4,076
Single nitrogen determinations :—		
Fresh faeces	634	
Urine	151	
Miscellaneous samples	82	
	—	867
Mineral analyses : foods, faeces, urine, grasses, etc.		206
Partial analyses of urine		3
Complete analyses of urine		116
Miscellaneous analyses of silage extracts, etc.		16
Total		5,563

III. Work of Section during 1927-28.

1. (*a*) *Experiments on nutrition of growing animals.* At Hosur an extensive feeding test with 56 animals has been carried out. Four fodders, *viz.*, (1) young spear grass silage, (2) young spear grass hay, (3) mature spear grass hay (80 per cent. spears removed) and (4) *ragi* straw, were compared with two rates of concentrate feeding, the concentrate consisting of a mixture of groundnut cake and rice bran in equal proportions.

The animals were divided into four groups, each being represented by the Scindi, Ongole and Kangayam breeds. Each group of fourteen was again sub-divided into two groups of seven each, one of them getting

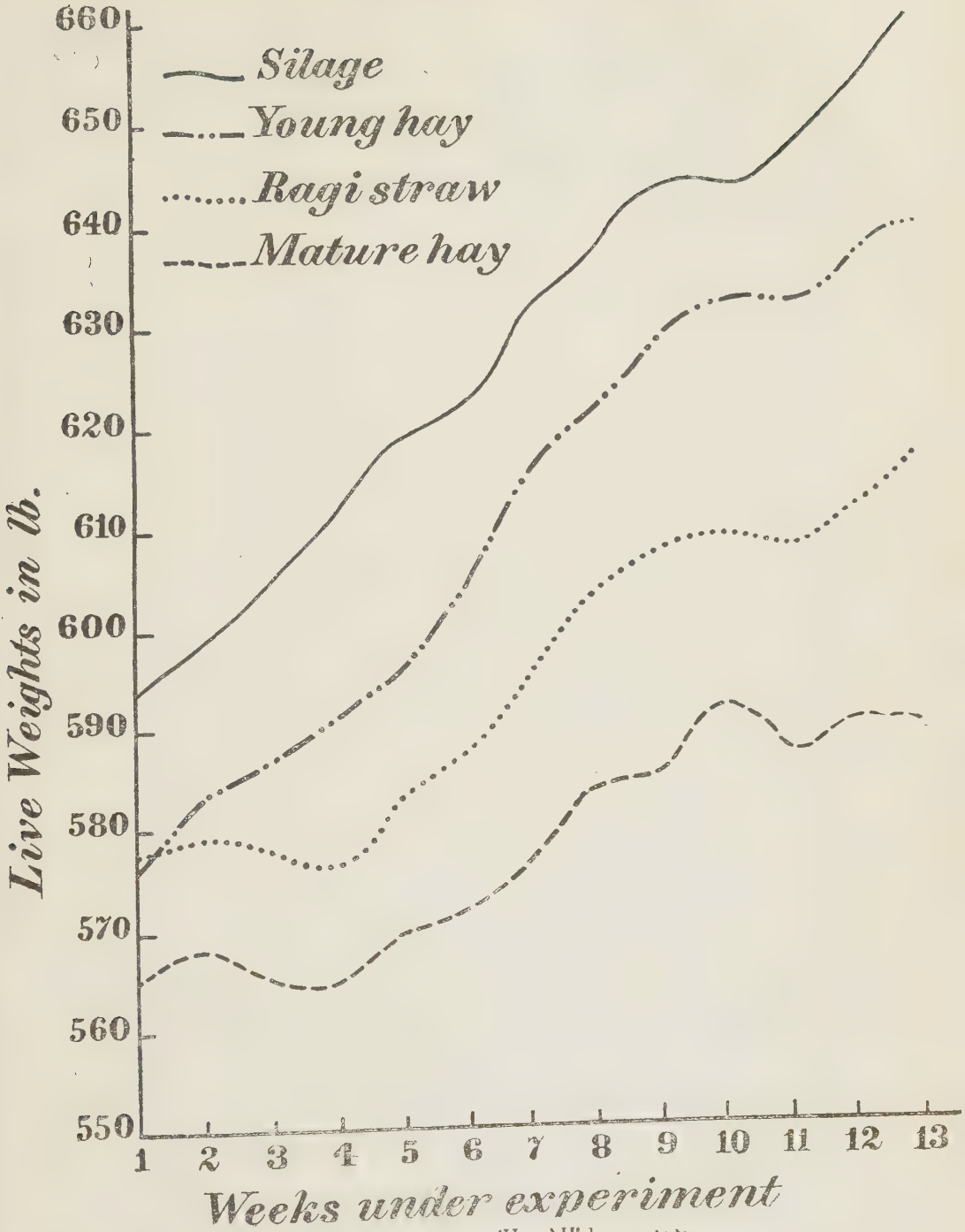

Fig. 1. Feeding Experiments (Hosur) High concentrates.

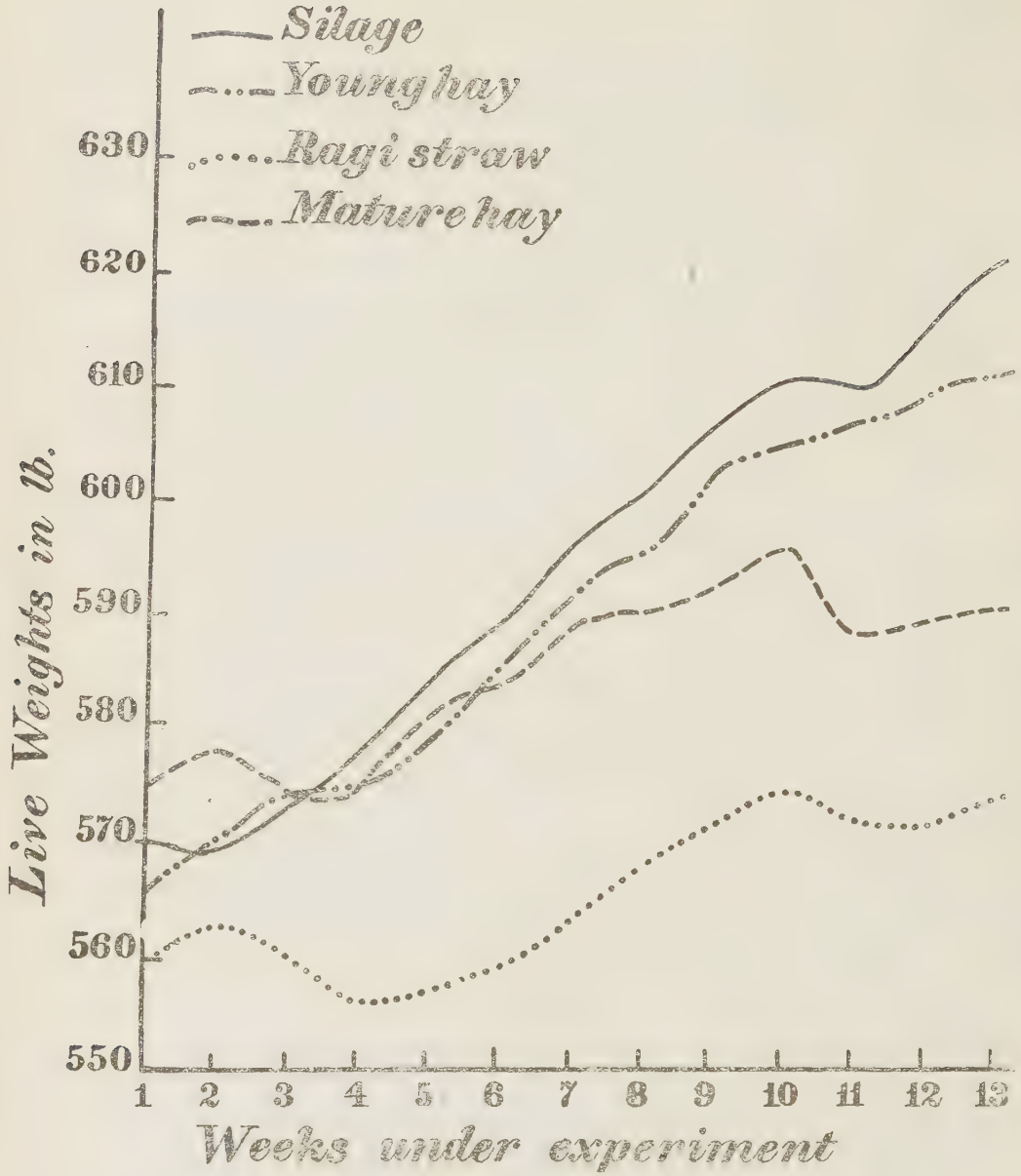

Fig. 2. Feeding Experiments (Hosur) Low concentrates.

a high concentrate allowance and the other a low concentrate allowance. As far as possible, the live-weights of the animals in one group were made to correspond with the live-weights of the animals in the other groups. All the roughages, except silage, were chopped and fed to the animals *ad lib.*, while the concentrate was given according to their live-weights, the standard followed being :—

TABLE I.

Weight of animals	High concentrate	Low concentrate
lb.	Grm.	Grm.
400	1,485	1,035
600	1,710	1,260
800	1,935	1,485

The intermediate in each case was obtained according to the weights obtained from the graph drawn according to the above standard. The animals were weighed daily and the concentrate allowance increased or decreased according to the live-weight average of the week. This feeding continued for twelve weeks and at the end of the period a digestion experiment was conducted with twenty animals, four animals from each of the low concentrate groups and four from the high concentrate young hay group.

The striking fact brought about by this experiment is that, generally, the silage animals fared better than the other groups as will be seen from Text figs. I & II. Even the silage animals with low concentrate allowance did better than the high concentrate animals of the other groups. Classified according to breeds, the Scindi breed did the best. In every case there was an increase of live-weight. This will form the subject of a detailed report after the results are fully tabulated and studied.

(*b*) At Karnal the first series of experiments has been concluded. Perhaps the most striking fact brought out by the Karnal work is concerned with the observed fluctuations in fodder consumption. It has been found that when the protein provided is low, fluctuations in fodder consumption become serious. When the protein is increased, the fodder is consumed more regularly. These peculiarities seem to be related to the nitrogen ratio of the ration. The subject is discussed fully in a paper which has been submitted for publication. It seems desirable to continue these useful experiments at Karnal. Proposals have been submitted for placing the work on a sound basis.

2. *Indian coarse fodders.* Long period feeding tests have been carried out with *juar*, *ragi* straw and hay. The experiments have been modified this year to study more thoroughly protein digestion and the effect of protein on carbohydrate digestion. The digestion experiments were done on three planes of nutrition, *viz.*, low, medium and high concentrate allowances. From a perusal of the figures in the accompanying table, it will be observed that the higher the protein allowance the lower the digestion of the total carbohydrate and organic matter, though very striking differences are not noticeable.

TABLE II.

	Fodder	Protein digested	Total carbohydrate digested	Organic matter digested
		Per cent.	Per cent.	Per cent.
1. Low concentrate	*Ragi* straw	2·7	63·8	61·8
	Juar hay.	58·3	66·2	64·7
2. Medium concentrate	*Ragi* straw	1·2	63·5	61·2
	Juar hay.	38·4	64·0	62·0
3. High concentrate	*Ragi* straw	21·9	61·0	58·9
	Juar hay.	56·6	60·1	60·1

The digestibility of protein of coarse fodders was referred to in the last report. This subject has been further studied during the long period digestion experiments mentioned above. From a perusal of the above table, it will be observed that the digestion co-efficient for the two fodders in the high concentrate experiment is considerably higher than the other two which is chiefly due to the high protein content in the fodders themselves as may be seen from the analytical figures given below.

TABLE III.

	Per cent. protein		
	1st	2nd	3rd
Ragi straw	3·06	3·06	4·25
Juar hay	7·5	6·0	10·06

Short period digestion experiments mentioned under this head last year have been continued. By this work the Section is collecting data for the preparation of digestibility tables of Indian fodders.

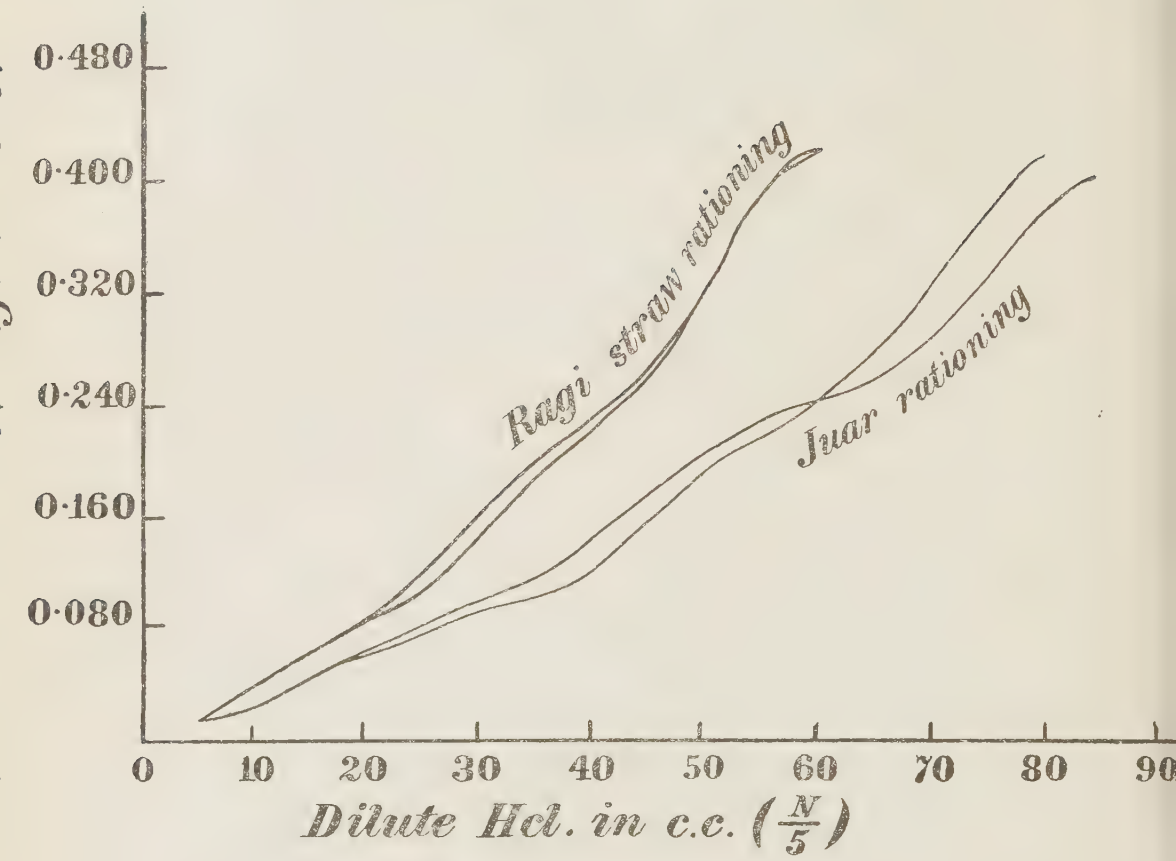

Fig. 3. Typical titration graphs of the urines produced by feeding Ragi straw and juar.

Diuresis. Observations on diuresis are being continued. This work has been extended to study certain important characteristics of cattle urine. Text fig. 3 shows typical potentiometric titration graphs of the urines produced by *ragi* straw and *juar* rationing respectively. The buffering of these urines is being studied and, in particular, attention is being paid to the parts played by CO_2 and hippuric acid.

Hippuric acid. The question of hippuric acid excretion has gained a new significance from the past year's work at Bangalore. In certain cases it has been found that the nitrogen excreted as hippuric acid exceeds the urea nitrogen, as may seen from part I of the following table (Low concentrate).

TABLE IV.

Roughages	Total	Nitrogen in 100 c. c. urine		
		as hippuric acid	as urea	
Juar hay . .	0·597	0·157	0·260	I. Low concentrate.
Ragi straw . .	0·355	0·120	0·057	
Juar hay . .	0·696	0·167	0·331	
Ragi straw . .	0·377	0·126	0·052	
Juar hay . .	0·650	0·164	0·293	
Ragi straw . .	0·351	0·118	0·056	
Juar hay . .	1·033	0·213	0·639	II. Medium concentrate.
Ragi straw . .	0·632	0·132	0·296	
Juar hay . .	1·106	0·214	0·556	
Ragi straw . .	0·630	0·132	0·295	
Juar hay . .	0·945	0·193	0·512	
Ragi straw . .	0·534	0·115	0·255	
Juar hay . .	1·217	0·147	0·752	III. High concentrate.
Ragi straw . .	1·270	0·141	0·920	
Juar hay . .	1·156	0·167	0·789	
Ragi straw . .	1·208	0·141	0·825	
Juar hay . .	1·089	0·159	0·809	
Ragi straw . .	1·146	0·124	0·760	

In such cases it is suspected that the nitrogen balance may be adversely affected by the formation of hippuric acid. Observations on this point will be undertaken. From the above table, it may also be noticed that the variation in the production of hippuric acid is due to the nature of the roughage fed and no appreciable effect is seen when the concentrate feed is increased.

The daily hippuric acid excretion under different systems of rationing has been studied in a few cases. Some typical results are shown in the accompanying table.

TABLE V.

Roughages	Nitrogen					
	In roughage and concentrate	In urine as hippuric acid	In roughage and concentrate	In urine as hippuric acid	In roughage and concentrate	In urine as hippuric acid
Juar hay . .	80·2	7·10	93·9	7·8	174·8	8·0
Ragi straw .	42·0	4·5	69·0	5·5	115·2	6·5
Juar hay . .	68·6	5·8	77·0	6·6	149·1	7·3
Ragi straw .	..	..	59·4	4·8	99·8	5·3
Juar hay .	66·7	5·6	..	..	143·1	6·2
Ragi straw .	36·0	3·9	57·6	4·7	96·0	6·6

The determination of hippuric acid. In the above and in other enquiries on which the Nutrition Section is engaged, it was found that the available methods for the determination of hippuric acid were not suitable. To meet this need, the new method has been devised by the Nutrition Section. The new method has given entire satisfaction and has greatly facilitated the enquiries in which the determination of hippuric acid is required.

3. *Mineral requirements of cattle.* A long period test to determine the mineral requirements of Scindi cows is in progress at Bangalore. The experiment has not led to definite conclusions so far.

4. *Indian pasture grasses and hays.* The work on Indian pasture grasses has been continued along the lines described in last year's report.

5. *Silage.* The main function of the Nutrition Section with regard to the silage problem must be to test the nutritive values of different silage types. It cannot undertake elaborate experiments on the manufacture of silage. However, silage testing involves silage manufacture and therefore the Section cannot avoid work on this subject. Tentative experiments on silage manufacture for feeding tests have been commenced this year and it is intended to expand these experiments considerably in the near future.

6. *Experiments on milk production.* The experiments undertaken last year have been continued without a break for twelve months. A study of the food consumption data seems to indicate that the animals did not do well to begin with and have improved steadily during the course of the test. This may be due either to improved health or to the fact that the animals took a long time to adjust themselves to the conditions imposed by the experiment. It may be mentioned that in previous experiments at Bangalore there was no evidence that the animals required a long time to become accustomed to the new routine. However, it may have been so in this case and therefore there is some doubt about the value of the rations provided. To clear up this doubt the experiment will be continued for some time. The following figures which give the herd average consumption data for successive periods of four weeks are interesting. It should be noted that fluctations in concentrate consumption indicate variations in milk yield as concentrate was accurately rationed according to the milk yield.

TABLE VI.

Herd average consumption data.

Periods	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th
	SCINDIS										
Concentrate . .	64	73	75	79	64	63	63	60	50	57	54
Roughage . .	128	140	135	114	126	128	132	119	115	126	126
TOTAL .	192	213	210	193	190	191	195	179	165	183	180
	CROSSES										
Concentrate .	157	151	149	147	121	121	104	89	73	62	58
Roughage . .	153	166	177	176	186	209	206	220	228	231	232
TOTAL .	310	317	326	323	307	330	310	309	301	293	290
	BUFFALOES.										
Concentrate . .	119	115	113	111	75	74	78	81	..	121	129
Roughage . .	229	240	251	240	248	286	309	345	..	332	349
TOTAL .	348	355	364	351	323	360	387	426	..	453	471

The data obtained with the Scindis and the cross-breds are very clear. The average Scindi cow whether in milk or dry eats 200 kilos dry matter in four weeks. The cross-bred eats 300 kilos. There is some evidence to show that the Scindi cow falls off in food consumption when she goes dry. With the cross-breds there is no striking fall in consumption. The table shows that as the concentrate allowance is reduced, the roughage consumption increases. In this respect the results obtained with cross-breds are most satisfactory. In the case of the buffaloes there is a very steady increase in food consumption. It would appear that the buffaloes did take some time to settle down to the routine and their further performance will be watched with interest.

IV. Training of Post-graduate students.

Five students went through the post-graduate course during the year under report.

V. Instruction provided for Dairy Diploma students.

The usual courses of lectures on chemistry and animal nutrition were given to the Dairy Diploma students.

VI. Co-operation with other Departments.

1. *Madras Department of Agriculture.* Feeding experiments on a large scale were carried out in co-operation with the Madras Department of Agriculture at Hosur. Much information of general value has been obtained from these experiments. A report on the Hosur work is being prepared. The herd of Ongole cows mentioned in last year's report was further tested this year.

2. *Military Farms Department.* The Section has received very valuable help from the Military Farms Department during the past year. We have been provided with some typical fodder samples and also an excellent set of samples for the study of the effect of maturity on nutritive value. These samples are being examined now.

3. *Bombay Department of Agriculture.* The work on pasture grasses is proceeding.

VII. Publications.

The comparative values of Sorghum Silage and fresh Guinea Grass in two parts. (*Journal of the Central Bureau for Animal Husbandry and Dairying in India.*)

Feeding Experiments at Karnal, 1925-26 and 1926-27. (*Memoirs Dept. Agri. India, Chem. Ser.*, Vol. X, No. 1.)

A Modified Method for the Determination of Hippuric Acid and Free Benzoic Acid in Urine of Cattle, by F. J. Warth, and N. C. Das Gupta. (Article in the *Biochemical Journal*.)

VIII. Programme of work for 1928-29.

Major subjects.

1. Experiments on the nutrition of growing animals. This work involves tests at Bangalore and Hosur.

2. A study of Indian coarse fodders, including determinations of maintenance rations and studies of nitrogen and mineral metabolism. This is a continuation of the systematic work commenced during the past year at Bangalore.

3. Mineral requirements of young stock and cows. Experiments at Bangalore and Hosur will be continued.

4. Examination of Indian pasture grasses. This work will be carried out in co-operation with the Military Dairy Farms and the Bombay and Madras Departments of Agriculture.

5. Experiments on milk production. A continuation of the work done last year.

Minor subjects.

1. A study of the chemical methods employed in the above enquiries.

2. Preliminary experiments for the initiation of work on other aspects of nutrition.

Training.

1. The training of post-graduate students, which is an important branch of the work of this Section, will be continued as usual.

2. For the Dairy Diploma students a course in general science, plant chemistry and nutrition will be provided by this Section.

REPORT OF THE GOVERNMENT SUGARCANE EXPERT.

(Rao Bahadur T. S. Venkatraman, B.A.)

I. Charge and Staff.

I held charge of the office of Government Sugarcane Expert and Mr. N. L. Dutt of that of Second Cane-Breeding Officer during the whole year. Eight members of the staff reverted to the Madras Department of Agriculture, and their places have been taken up by fresh men. The Assistant Sugarcane Expert was in immediate charge of accounts and routine work.

The research work carried on directly under the Second Cane-Breeding Officer and bearing mainly on the breeding of thick canes is detailed in Section V. This breeding of the thick type of canes was started but recently in 1926.

II. Research and Investigations.

(*a*) *Cane-breeding technique.* (*i*) *The Coimbatore isolation method.* The isolation of live arrowing canes after artificial rooting [1] once again proved a complete success with thin and medium canes. The very large number of hybrid seedlings obtained with this method during the year proves that the seed setting in the treated arrows is not adversely affected. The method enabled the raising of a large number of seedlings, over 10,000, of a desired cross with a high degree of certainty in the matter of parentage.

(*ii*) *Influencing time of arrowing.* In spite of recent improvements in technique, there still exist varieties which it has not yet been possible to cross *inter se* on account of the difference in their times of flowering. There are two ways in which this could be overcome, *viz.*, (1) preservation of pollen in viable condition till the later variety arrows and (2) hastening or retarding the arrowing of one or both varieties. The former is receiving attention from the Second Cane-Breeding Officer and is referred to later in the report. In regard to the latter, it has been noticed in the past that (1) canes arrow distinctly late under saline soil

[1] Venkatraman, T. S., and Thomas, R. Sugarcane-breeding Technique—Isolation of live arrows from undesired Pollen through artificial rooting of canes. *Agri. Jour, India,* Vol. XXI, Pt. 3, May 1926.

First ground nursery (season 1928, with 200,000 seedlings, mostly hybrids) at the Imperial Sugarcane-Breeding Station, Coimbatore.

conditions and (2) that the time of planting has some effect on the time of arrowing. Experiments have been laid on the basis of the above for securing closer approximation between the flowering periods of canes.

(*iii*) *Nursery.* A minor but very effective improvement was effected in the lay out of the first ground nurseries. Long narrow beds, 60 feet $\times 2\frac{1}{2}$ feet, are formed and veins of sand are laid across the beds at intervals of two feet and also a central vein along the length of it. Such an arrangement secures for the beds a more uniform irrigation (when the water is let in) and drainage (when the water is cut off). The sand veins apparently act as sponges and a marked improvement in the health and vigour of the seedlings has resulted from this arrangement.

(*b*) *Root studies.* (*i*) *Role of sett roots.* One of the first activities of the planted cuttings is the development of roots from the root eyes in the cutting or sett. These we might call '*sett*' roots. Sugarcane varieties show interesting differences in the number of sett roots that are thus developed soon after planting. It is found that, whereas for the swelling or bursting of buds, the development of sett roots is not essential, they are so for the proper development of the bud into a shoot. In certain varieties, roots develop only from a certain number of root eyes ; the rest remain dormant and develop roots when a need arises. This is perhaps a definite provision against adverse conditions during the early stages of growth. Irrigation with saline water appreciably inhibits the growth of sett roots.

(*ii*) *Role of 'shoot' roots.* The sett roots die after a short time ; and after this the growing plant depends for its nourishment on other roots which develop from the shoot. A positive correlation has been noticed between the development of these '*shoot*' roots and the growth vigour of the plant. If the plant is deprived of the shoot roots as they are developed, its vigour suffers in an appreciable manner. *It would be an advantage to the crop if facilities are afforded for an early and rapid development of shoot roots.* Earthing up the crop at the right time is one means of securing this.

(*iii*) *Root system of the adult plant.* Like the sett roots, the first shoot roots also die after a time and their place is taken up by other roots which develop from fresh shoots or from fresh joints in the older shoots. The cane plant in the adult stage produces almost a continuous series of new roots. If under experiment the plant is prevented from developing such new roots, it gradually loses vigour and dies out. *Frequent production of new roots would thus appear to be an essential condition for satisfactory growth in the sugarcane and cultivation operations should be designed to secure this.*

On account of this frequent production of fresh roots, the root system of a cane plant varies appreciably from time to time when periodic root dissections are made in the field. This is perhaps of some advantage to

the plant, as it is thus able to adjust its root system to changing conditions in the environment with a considerable amount of nicety.

It would obviously be a great advantage if the characteristic root system of each variety and seedling be worked out. It would help to guide the cultivation operations with the maximum of advantage to the crop and give valuable indications as to the conditions wherein the particular variety is likely to do its best. The task, it needs to be mentioned, however, is rather laborious ; and to arrive at the typical root system of any cane, dissections of the cane will have to be done under different conditions of growth, as the root systems are profoundly influenced by environmental conditions.

(*iv*) *Aerotropism.* Roots of most canes—chiefly of the tropical types—are positively aerotropic. There are, however, interesting differences which are well brought out by growing canes in water culture. Certain seedlings, derived from the grass *Saccharum spontaneum*, have grown easily in water culture and some of these have withstood water-logging conditions in a remarkable manner.

(*c*) *Breeding canes against animal attacks.* The sugarcane crop in the field is liable to damage from various animals. Rats, jackals, porcupines and wild pigs are the more common of such depredators under Indian conditions. This liability starts at a fairly early stage in the life of the crop, in fact almost immediately after the commencement of cane formation in the plants. In the sugarcane the bottom joints mature and contain a fair amount of sugar long before the cane as a whole is ripe.[1]

There are two ways of minimizing loss from animal attacks. A suitable fencing could be erected to keep out the animals or a cane selected for growing with the rind sufficiently hard to resist such attacks. The former is rather expensive and in the opinion of the Royal Commission on Agriculture in India only a palliative.[2] The latter method, if at all possible, would be of considerable practical value especially in areas like the sub-tropical regions of Northern India where the ryot is not prepared to spend very much on the growing and tending of his cane crop.

This subject has been receiving attention for some time, and in certain recent hybrids, markedly hard rinded parents were employed with this object. It was felt, however, that in this work it would be a great help to have some means for comparing varieties and seedlings with one another with a fair amount of definiteness. Dr. A. N. Puri, the Physical Chemist at the Imperial Agricultural Research Institute, Pusa, kindly designed for me such an apparatus. With its help the relative rind hard-

[1] Venkatraman, T. S., and Krishnamurthi Rao, K. Study of the sucrose variations in successive cane joints as they attain maturity with special reference to the death of leaves. *Agri. Jour. India, Special Indian Science Congress Number*, 1917.

[2] Report of the Royal Commission on Agriculture in India, page 121, para. 116.

nesses could be expressed in terms of a weight measure. The table below indicates the utility of this apparatus in determining rind hardness.

Relative rind hardness of sugarcane varieties expressed in lb.

Variety	Remarks on rind hardness based on experience		Weight in lb. needed to pierce the rind	
Keli	Softest cane in Madras collection.	Tropical canes.	2·5	
Seri Bontha	Soft canes	Tropical canes.	3·9	The piercing bit was 1 mm. diameter.
Poovan	Soft canes	Tropical canes.	4·4	The piercing bit was 1 mm. diameter.
Bontha	Soft canes	Tropical canes.	4·6	The piercing bit was 1 mm. diameter.
Bithur Pounda	Soft canes	Tropical canes.	4·7	The piercing bit was 1 mm. diameter.
Patta Patti	Soft canes	Tropical canes.	5·2	The piercing bit was 1 mm. diameter.
Yuba	Indian canes		7·0	
Chunnee	Indian canes		7·6	
Co. 205	Hard rinded seedlings.	Coimbatore	9·2	
Co. 213	Hard rinded seedlings.	Coimbatore	8·2	
Co. 219	Hard rinded seedlings.	Coimbatore	8·9	
Co. 223	Hard rinded seedlings.	Coimbatore	8·0	
Saccharum spontaneum	Wild grass		10·3	

NOTE. The above figures represent the average of readings taken of the bottom six joints—six readings per joint. Attacks from smaller animals are often confined to the bottom portions of canes.

(*d*) *Mosaic resistance.* Mosaic disease has recently been attracting attention in India and, sooner or later, resistance to this disease might constitute a fairly important consideration in the selection and distribution of varieties and seedlings in this country.

Though different views are entertained as to the exact nature of mosaic and the actual method of transmission, there is a general consensus of opinion that the disease is insect-borne. An attempt was therefore made to examine susceptible and resistant varieties for any leaf adaptations that may render the resistant ones less comfortable for the insect-visitor.[1] The investigation has only been recently started; and very interesting lines of work have already presented themselves. Considerable work, however, will be needed before definite conclusions could be drawn on this rather elusive but very important disease.

[1] Venkatraman, T. S., and Thomas, R. A leaf adaptation conducive to mosaic resistance in the sugarcane. *Agri. Jour. India*, Vol. XXII, Part 1, January 1928.

Co. 205—a cross between a tropical cane and the Coimbatore *Saccharum spontaneum*—has shown a certain amount of susceptibility to mosaic. This was rather a surprise in view of the reports from elsewhere that *Saccharum spontaneum* hybrids are resistant to mosaic. An examination has shown, however, that the *Saccharum spontaneum* as used in Java is rather different from the one generally known as such in India.

(*e*) *Inheritance of characters.* Over 10,000 hybrid seedlings between Co. 213 and Co. 214 were obtained and 4,000 of these planted for a fairly detailed study. This is an interesting lot and includes types very similar to the various parents employed in building up the two canes (Co. 213 and Co. 214). Both Co. 213 and Co. 214 have the *Saccharum spontaneum* blood in their great-grand-parents and among these 4,000 there are at least two seedlings which are very similar to *Saccharum spontaneum.* The value of such a study would be largely academic and such attention will be devoted to it as the strength of the existing staff would allow.

(*f*) *Morphological descriptions.* Five of the more popular Coimbatore seedlings—Cos. 205, 210, 213, 214 and 223—were described during the year. The descriptions were designed mainly to help the intelligent and observant grower in separating out the canes, should they inadvertently get mixed in the fields. A study of the root systems was included and it is hoped to be able to make such studies a regular feature of such descriptions in the future. Root studies are more laborious than descriptions of external characters but their utility is obvious. A second batch of seedlings is to be described during the next year and their root studies have already started.

III. The Breeding of Sub-tropical Canes.

When the Coimbatore station was started in 1912 the aim was to replace the canes in cultivation with seedlings which would be improvements on the extant canes. This has been achieved in the main cane growing provinces of North India ; and in the opinion of the founder of the station—Dr. C. A. Barber, C.I.E.—the increased gain from the new productions has been " very far beyond the wildest hopes " entertained at the time.

As was to be expected, the growers want further improvements and a closer adjustment to the varying conditions of growth in their localities. This, together with a greater knowledge of the growth conditions in sub-tropical India, is necessitating a wider combination of parents. In a recent combination as many as sixteen parents were employed.

The following are mentioned to indicate the manner in which the breeding at Coimbatore is made to meet the prevailing growth conditions in North India. Soon after the first stages of germination, the cane crop in North India passes through a period of comparative drought ;

and, in the recent selections, an early development of a fairly deep root system has been made an important criterion for selection. Secondly, damage from shoot-borers is by no means uncommon over certain tracts. Past experience has indicated that canes which tiller early survive the attack better than others which tiller late ; in the latter case the one mother shoot, if dead, often means the death of the plant as a whole. Root studies undertaken at Coimbatore have shown that an early and vigorous shoot root development directly contributes to early and vigourous tillering. In the new combinations the parents employed are chosen with this view point.

IV. The spread of Coimbatore canes in Sub-tropical India and the increased money value resulting therefrom.

One satisfactory feature of the year has been the further spread into cultivation of Coimbatore canes in the United Provinces which have the largest concentration of cane area in India. The Director of Agriculture of these provinces observes as below about a recent seedling, Co. 290 :—

> "A new sugarcane (Co. 290) received from Coimbatore in 1924 has proved suitable for all sugarcane areas in this province. It is superior in quality to Co. 213.
>
> * * * * * * *
>
> Co. 290 is in the opinion of the writer the best seedling cane yet produced at Coimbatore. It has been selected for wide distribution throughout the province and will materially assist in raising the standard of sugar production."[1]

This seedling was deliberately bred and selected as an improvement on Co. 213, and it is satisfactory that in the largest cane-growing province in India it should prove to be so.

That Co. 281 is proving useful in Cuba was mentioned in my previous report. It is continuing to make headway in that island and according to a recent communication " several thousand acres " will soon go under this seedling. A very recent communication from Florida runs—

> " It may be of interest to you to hear that Co. 281 is showing up very well under our rather difficult conditions of climate and soil and it looks now as if it would be one of our best, if not our very best cane."

The seedling Co. 290 as well as Co. 281—the usefulness of which appears so far to be confined to the New World—are recent productions.

[1] *Report on the Administration of the Department of Agriculture for the year ending June 30, 1927, United Provinces of Agra and Oudh*, page 4.

These were selected and distributed as late as 1924 which shows that the useful canes are by no means confined to the work of the earlier years. It needs perhaps to be mentioned here, however, that it was not till a rather radical change was made in the parents employed that these were obtained.

In the report for 1926-27 the area under Coimbatore canes in North India was estimated at 23,600 acres and the increased profit to cane growers placed at rupees fourteen and a half lakhs (14,50,000). During the year the area under Coimbatore canes in North India rose to the neighbourhood of a lakh of acres (100,000) with more than a proportional increase in profits. When it is remembered that the annual recurring expenditure on Coimbatore is a little over half a lakh, the return to the country might well be considered satisfactory. It needs no mention here that the area and hence the profit to all concerned would rapidly increase in the future.

The Coimbatore station has knocked the bottom out of the belief, once widely held, that good tonnages could not reasonably be expected from the main cane-growing provinces of sub-tropical India. In spite of the necessarily short period of growth as a result of the prevailing weather conditions—drought and extreme heat during the early stages of the crop and inhibitive cold towards harvest—the Coimbatore seedlings have yielded tonnages comparable, in no small measure, to those obtained in other parts of the tropical world, when some allowance is made for the inevitably short growing period. The sugar factories in Northern India have also shown an appreciable improvement in equipment and efficiency during recent years. It is to be hoped that the future developments will be such as to nurture and develop an industry connected with an essential and much needed article of food. During the year 1926-27 India had to purchase over 18 crores rupees worth of sugar from outside.

V. Research and Investigations bearing mainly on Thick Cane-Breeding under The Sedond Cane-breeding Officer.

(N. L. Dutt, M.Sc.)

(*a*) *Flowering habits of canes.* The studies on the time taken for the complete emergence of the arrows in the different varieties, the length of the protruded arrows when the flowers open for the first time, the time of the opening of the flowers, the time of the bulk dehiscence of anthers, the interval between the full emergence of the essential organs of the flower and the bulk dehiscence of the anthers, and the effect of the prevailing weather conditions on these, referred to in the previous year's report, were continued. In addition, analyses were completed

of the bulk and special collections of anthers at the different stages of the growth of the arrow. The above mentioned observations were very useful in shaping the hybridization programme during the year.

(*b*) *Pollen studies.* (*i*) *Artificial germination.* In addition to the varieties taken up last year, which were redone for corroboration, germination tests were conducted for quite a number of other thick cane varieties. Fairly long pollen tubes and a good number of germinations were obtained. To the list [1] of varieties that gave good pollen germination, the following can be added, as a result of this year's test :—

B. 3412	D. I. 52
B. 1528	S. W. 111
B. 254	N. G. 24 B
Q. 813	and
Q. 116	D. 1135

(*ii*) *Culture medium.* While trying the culture medium evolved last year, it was found that equally good germinations are obtained by substituting the ordinary commercial white sugar for sucrose, thus enabling a quick and cheap test of the viability of pollen without resorting to chemically pure sucrose.

(*iii*) *Presence of rudimentary pollen.* During the course of observations on pollen, not a little percentage of the pollen of certain thick cane varieties was seen to be aborted. In sugarcane breeding anthesis has so far been the only criterion of a variety for its being utilized as a male parent ; but as even widely open anthers or a high percentage of such open anthers may contain a good number of aborted or ill-formed grains, it would seem that the success or otherwise of a variety as a pollinating parent depends on the percentage of normal and healthy grains. Percentage of aborted and healthy pollen was worked out for twenty-three varieties, the counts showing a high percentage of unhealthy pollen for Kaludai Boothan, White Mauritius, Co. 213, Gillman, Striped Cheribon, La Purple and B. 254.

(*iv*) *Viability.* As it is often desirable to make a cross between varieties whose flowering time differs by three weeks or more, and which is not practicable owing to the unavailability of viable pollen, an attempt was made to keep the viability of sugarcane pollen. Mauritius 131 pollen was successfully kept viable for 120 hours (five days) in corked and paraffined glass tubes at low temperatures ranging from 9° to 13° C. Considering the fact that graminaceous pollen has not been kept viable for more than three days, this would appear to be an advance, but in as much as the ideal is to store alive the cane pollen for four weeks or so, this experiment will need to be continued next year. Attempts to

[1] Dutt, N. L., and Ganapathy Iyer, G. Germination of Sugarcane Pollen in Artificial Culture Media. *Agri. Jour. India*, Vol. XXIII, Pt. 3, May 1928.

store sugarcane pollen in CO_2 and at definite relative humidities were not successful.

(*c*) *The Seed.* (*i*) *Germination.* Owing to poorer germination of the thick cane seeds last year, it was felt that there was a scope for improvement in the technique at least so far as the drying and spreading of the fluff in the seed pans was concerned. The adverse weather conditions that prevailed during the last season hindered the proper drying of the collected arrows. Fluff freshly collected from the field was dried in the oven for 24 hours at 40° C. and then sown in the pan in the usual way. The resulting germinations were as good as in the case of the seed from the same arrow dried in the sun for three or four days. This promises to be helpful in cases of rainy or persistently cloudy weather not uncommon during the cane flowering season at Coimbatore when it would not be possible to dry the seed in the sun.

The fluff was mixed with an equal quantity of slightly moistened potting mixture and spread over the seed pan, the pan being watered in the usual manner. It was found that this soil-fluff mixture gave uniformly better results than the common method of sowing.

(*ii*) *Viability.* With a view to test the viability of thick cane seed, germination tests were made at specific intervals from the date of collection of the seed. A few germinations were obtained from the seed of P. O. J. 2725×P. O. J. 2696, Gillman × E. K. 28, S. W. 111 G. C., five months, and Co. 213×Gillman, six months after the date of collection of seed.

(*d*) *Hybridization and selection.* Based on the last season's observations regarding the flowering habits of the thick type of canes, a programme was drawn up for the male and female varieties to be employed in the hybridization campaign. The main programme was to get ideas about the type of seedlings that the various thick cane varieties give rise to, and with this end in view, artificial rooting was induced in twenty-one reputed thick canes with the object of getting self-fertilized seed. These were isolated into temporary sheds with removable tops, care being taken to locate these fairly apart to safeguard against unintended pollen. Crossing operations were restricted to five varieties known to be good female parents and to eight pollinating varieties.

The crossing during the season was satisfactory, and a number of varieties flowered that failed to do so last season. The seedlings were raised in the Thick Cane-Breeding Area itself, and as the Seedling House land was utilized for the first time for growing and keeping germinated sugarcane seeds, measures had to be taken against ants and termites from which considerable trouble was experienced, while the land was brought into condition and improved by crow-barring and addition of tank silt and sand.

Germinations were good in crosses with general collections coming second, but the selfs were a disappointment. Of the twenty-one varieties that were selfed only two, *viz.*—Co. 213 and Striped Cheribon—yielded one seedling apiece. The failure of the selfs is attributable to the systematic attack of white ants on the isolations in the selfing sheds. A total of 60,000 seedlings was available, out of which 12,000 were transplanted to the Second Ground Nursery. At the time of transplanting the seedlings were classified according to general field characters in order to establish correlations, if any, with the characters at maturity.

The question of naming the thick seedlings, while under the preliminary trials at the station, came up for consideration. The sub-tropical types during the preliminary stages of trial are called 'M's. It was decided to call the thick types 'P's—in view of their resemblance to the Indian *Pounda* canes—till they are distributed when they will be called 'Co.'s like the rest of the productions from Coimbatore.

In conjunction with the Government Sugarcane Expert, twenty-seven P's from the 1925-26 lot and 150 P's from the 1927-28 Second Ground Nursery, were selected. The selection of the 1925-26 seedlings was based on their polarization and total solids figures as well as performance in the field, while that of 1926-27 seedlings on growth and habit characters alone.

(*e*) *Root dissections.* The root systems of thirty varieties important in thick cane-breeding were dissected, and careful drawings made of the lateral spread and depth of the roots. The root dissections were proceeded with, considering that, as the success or otherwise of a sugarcane seedling or variety depends not a little on the type of its root system, definite knowledge about the root systems of the parents employed in breeding is necessary.

Should the experience of the medium and thin cane section of the Imperial Sugarcane Breeding Station, Coimbatore, in being able to combine deeper rooting qualities with other suitable characters by introducing the blood of certain Coimbatore productions be applicable to the thick cane work at the station, it will afford an important line of attacking the problem.

VI. Receipt and Despatch of Canes.

During the year twenty-four cane varieties were received from overseas. These included twelve from Java, one from Mauritius and nine from Washington. The Java imports are of their recent promising seedlings and the Washington consignment included mosaic resistant varieties.

Over eighty packages of canes were despatched from the station after examination by the Government Mycologist and the Government

Entomologist to whom my thanks are due. The Phillipines, Java, Russia and the United States of America were some of the recipient countries.

VII. The Farm.

The deep and narrow trenches round cane fields, originally intended for drainage and for cutting off outside tree roots, were utilized for yet a third purpose. Trash as it was collected from the crop was placed in these trenches with alternate thin layers of the contents of the loose box to convert the trash into manure.

Minor improvements were made in the labelling of cane plots, ferro-concrete posts and twisted wire being employed for the same.

Certain new roads were laid, live fences strengthened, appreciable progress made in the closing of useless wells and borings undertaken in two of the wells for improving water supply and with some success.

The old area at the station has at present only one well on which to draw for irrigating canes. After many trials a spot was selected for a second well to utilize fully the available land. A bore-hole on this spot has yielded water which has been reported on by the Director, King Institute, Guindy, Madras, as " chemically the best so far examined from Coimbatore."

VIII. Co-operation with Provincial and Overseas Departments.

Plots of canes were planted for the Madras Government Agricultural Chemist, to see if setts obtained from a well-manured plot would yield better growing material than setts from plots not manured or manured in a defective manner. Other plots were laid for the Government Mycologist and the Government Entomologist, Madras.

Investigations at Coimbatore have brought in offers of co-operation from Sugarcane Research Stations overseas, and there has been a constant interchange of experience and information with such stations. The recently founded " International Society of Sugarcane Technologists " with its triennial conventions in the leading sugarcane countries of the world is materially contributing to a feeling of comradeship among research workers on the sugarcane.

IX. Miscellaneous.

I presided over the Agricultural Section of the Indian Science Congress held at Calcutta in January 1928.

At the behest of His Excellency the Viceroy during the time of his visit, a demonstration was arranged for and invitations sent to officers in the provinces working on sugarcane.

During the year building constructions worth over Rs. 76,000 were got through and the new Office and Laboratory occupied in March 1928.

The visitors included Their Excellencies the Viceroy and the Vicereine who spent a good half hour at the station, His Excellency the Governor of Madras, Mr. F. E. Devoto from the Argentine Republic, the Agricultural Adviser to the Government of India and various officers from Pusa.

The receipts during the year amounted to Rs. 7,039-1-7 (of which Rs. 1,154-14-0 was by way of rent for residential buildings).

X. Programme of Work for 1928-29.

Major.

The breeding of medium canes will be continued with the object of securing further improvements or covering new tracts.

The breeding of thick canes to suit the requirements of peninsular India will be carried on.

Further attempts will be made to improve the breeding technique and to secure greater germination among thick cane seeds.

Minor.

Studies on root development and viability of sugarcane pollen and sugarcane seeds.

Study of rind hardness in canes.

Study of possible adaptations for mosaic resistance.

Morphological studies of varieties and seedlings as also of the flowering habits and floral characters of important parents.

XI. Publications.

Venkatraman, T. S.; and Vittal Rao, U.	Coimbatore Seedling Canes. (Co.'s 205, 210, 213, 214 and 223 described and illustrated.) *Agri. Jour. India*, Vol. XXIII, Pt. 1, January 1928.
Venkatraman, T. S. and Thomas, R.	A Leaf Adaptation Conducive to Mosaic Resistance in the Sugarcane. *Agri. Jour. India*, Vol. XXIII, Pt. 1, January 1928.
Venkatraman, T. S.	The Indian Sugar Bowl and Agricultural Research in connection therewith. (Presidential Address, Agri. Section, Indian Science Congress, 1928.) *Agri. Jour. India*, Vol. XXIII, Pt. 3, May 1928.
Dutt, N. L.; and Ganapathy Iyer, G.	Germination of Sugarcane Pollen in Artificial Culture Media. *Agri. Jour. India*, Vol. XXIII, Pt. 3. May 1928.
Krishnamurthi Rao, K.	Factors influencing the growth and sugar contents of sugarcane. (Read at the Indian Science Congress, Calcutta, 1928.)

REPORT OF THE SECRETARY, SUGAR BUREAU.

(Wynne Sayer, B.A.)

I. Prefatory.

I held charge of the office of Secretary, Sugar Bureau, throughout the year under report except for one month in February, 1928, when I was on training for the Army in India Reserve of Officers at Lucknow and in March-April (22nd March to 21st April) when my services were lent, through the Government of Burma, to Messrs. Finlay, Fleming and Co., Rangoon, to advise them in connection with the questions of sugarcane cultivation, manuring, etc., on their estate at Sahmaw in Upper Burma. Rao Saheb Kasanji D. Naik, Superintendent of my office, on these occasions was placed in-charge in addition to his own duties.

The Bureau is now in its tenth year of existence on a temporary footing and its work is much handicapped by reason of this hand-to-mouth existence.

During the year under report the Bureau continued to collect and make available to the public and the Provincial Departments information relating to sugarcane cultivation, sugar manufacture and the sugar trade in India and abroad.

II. Agricultural.

On the agricultural side, the actual work of growing and testing exotic varieties as well as cross-bred seedling canes from Coimbatore was transferred to the Imperial Agriculturist in 1926-27, but the Secretary, Sugar Bureau, remained in close touch with the work and assisted and advised both the Imperial Agriculturist and the Government Sugarcane Expert regarding the selection of the types of cane required. Further testing of the canes, proved of suitable type at Pusa, is conducted by the Secretary, Sugar Bureau, at three outstations, *viz.*, Dowlatpur, Bhicanpore and Lohat. The following varieties were under test at these places—

(1) Dowlatpore—Co. 205, 273, 275, 280, 281 and 290.
(2) Bhicanpore—Co. 273, 275, 280, 287 and 290.
(3) Lohat—Co. 205, 273, 287 and 290.

Co. 287 and Co. 290 have proved successful in these tests, while Co. 205 has now been well established on low-lying lands and on high lands where hard conditions are met. On non-irrigated areas Co. 290 has not yet been found to display that tillering power which is associated with Co. 213 and its tonnage is therefore frequently lighter.

At Marhowrah, in Saran District, an experimental plot was laid down in close collaboration with the Deputy Director of Agriculture, Western North Bihar Range, to ascertain whether the view held by many large growers and cultivators that Co. 213 could not be grown successfully in that district was based on facts. The results show that this general view is erroneous. By constant touring a watch was kept on the behaviour of the four varieties (Co. 210, 213, 214 and 205) already selected and distributed by the Secretary, Sugar Bureau, in North Bihar, and openings for a new type of cane were reported to the Government Sugarcane Expert.

The scheme relating to cane propaganda work sanctioned by the Bihar Government worked satisfactorily and proved its utility. Under this scheme one Overseer worked under me throughout the year. He assisted in examining and selecting seedcane blocks of big and small growers and demonstrating the improved methods of sugarcane cultivation and manuring. He visited some 17 estates and 60 villages in the districts of Darbhanga, Champaran, Saran and Muzaffarpur. He assisted growers in rogueing out the clumps affected with mosaic and was also employed in finding out the average percentage of mosaic infection in different varieties.

Messrs. Begg Sutherland and Co., who are managing agents of several factories in the white sugar tract, distributed free of cost some 13,000 maunds of seedcane in the Marhowra Circle which feeds their factory at Marhowrah and another 10,000 maunds of Co. 205 and 210 in the Ryam Circle. They are thus assisting in the most useful work of replacing the inferior varieties by superior cross-bred canes. Factories in the white sugar tract are also encouraging the cultivation of improved Co. varieties in another way, *viz.*, by giving a premium over the local canes. The cultivation of these cross-bred canes in the Gorakhpur District has appreciably advanced, as the cultivators find that these new varieties not only yield more but also fetch a higher price when offered to factories. While these results with Co. canes are satisfactory, they do not go far enough. The most urgent necessity of the sugarcane industry in this country is to increase the tonnage per acre. With the fall in the price of sugar, which indirectly affects the *gur* market also, it is essential to increase the yield per acre if sugarcane cultivation is to continue to be profitable to the ryot. The spread of P. O. J. 2878 over a large part of Java, which has enabled that island to increase its output by 20 per cent. without any appreciable extra cost (output

in 1927, 2,360,000 tons and output in 1928, 2,900,000 tons estimated), has lowered the cost of production of white sugar in Java to 11½ guilders per 100 kilos (=Rs. 4-10-0 per maund), and this exposes the whole Indian sugarcane industry to an intense struggle for its very existence. The evolution of even higher yielding seedling canes and improved methods of agriculture so as to get the best out of the land are therefore most urgently called for. In this connection it is also pertinent to stress the pressing necessity of giving growers a high yielding early ripening cane so that the factories may be enabled to start the campaign earlier and thus spread their overhead charges over a much larger crop. Co. 214, which is the only early ripening cane crushed with the exception of Baraukh, the indigenous swamp cane, is not a tonnage cane and is consequently not in favour with the growers unless an inducement in the form of a premium is given together with an assurance that all this cane will be taken off by the end of November. Now that the factories have improved their milling and boiling house equipment, the main desideratum is *increased supplies of cheap cane per acre.*

Turning to work in the provinces, I was appointed, as mentioned in last year's report, a member of the Sugar Sub-Committee of the Punjab Joint Development Board and attended several meetings of that Committee with a view to give them technical advice regarding the group of sugar factories, the economic possibility of which the Committee was examining for certain tracts in the Punjab. The Committee made its recommendations and has since been dissolved. Arrangements are now in train to put up one factory near Soneput in South-East Punjab and if this is found a success, others will follow in the sites chosen by the Committee.

The Karnal Farm is situated in this tract and the cane growing work now in progress there will be of great help to the local industry. Co. 213 has already been given out and has proved successful. Co. 287 and Co. 290 are also under trial and it is hoped will suit the prevailing conditions.

Reference was made in last year's report to the requisition for the services of the Secretary, Sugar Bureau, by the Government of Bombay to advise them in connection with the cultivation of sugarcane under irrigation on the Deccan Canals where it has in many instances been found unremunerative. I thoroughly examined the whole question and five visits were paid by me to the tract. A report was submitted to the Bombay Government and the recommendations made are engaging the attention of the Local Government.

My services were also lent to Messrs. Finlay, Fleming and Co. from 22nd March to 21st April, 1928, to guide them in placing the cane cultivation at their pioneer factory at Sahmaw in Upper Burma on a sound basis. A comprehensive report on the whole estate was drawn up for

the improvement of cultivation practices, the varieties to be tested and planted, the manuring to be adopted and the rotations to be followed. It is hoped as a result of the adoption of these recommendations the supplies of cane will be assured to their factory in the near future.

Mosaic. This disease continued to engage the serious attention of the Mycological Section as will be seen from the report of the Imperial Mycologist. Fortunately Co. 214 is highly resistant to this disease, while Co. 210 may be classed as resistant; the percentage of infection in Co. 213 though fairly susceptible is negligible. Co. 205 which is very susceptible is infected up to 15 per cent. and though its vigorous growth and hardy nature stand it in good stead, systematic rogueing and seed selection are being recommended to growers as it is impossible to tell whether the yearly attacks of this disease if left unchecked will not ultimately affect tonnage. An article on mosaic control in other cane-growing countries was compiled during the year and sent for publication in " The Agricultural Journal of India ".

III. Industrial.

The number of factories in India remained the same during the year under report. Two new sugar concerns at Basti and Lachmiganj in the United Provinces are under construction and will probably work in the season 1928-29.

As usual the Bureau kept in touch with all sugar factories in this country and brought to their notice the names of duly qualified candidates seeking employment in the mills. Statistical returns for the working season 1926-27 were obtained from factories and refineries in India; and a consolidated statement of total production of sugar in India was compiled and published in " The Indian Trade Journal " and " The Agricultural Journal of India ". The production of sugar direct from cane in 1926-27 amounted to 62,941 tons as against 52,995 tons in the previous season; the total quantity of sugar refined from *gur* rose from 38,409 tons in 1925-26 to 58,085 tons in 1926-27. Thus the total production of sugar in India was 121,026 tons in 1926-27 as against 91,404 tons in 1925-26. It may be mentioned that nearly half the number of refineries are silent this year as the prospective low price of sugar and the comparatively high price of *gur* leave an insufficient margin of profit to work on. The molasses market has also slumped in North India.

If we take a review of the last three seasons' average percentage recovery of sugar direct from cane in the sugar factories of Bihar, United Provinces, Bombay, Madras and Burma, we find that there is a steady increase in all the provinces. It will also be seen from the

following table that the average percentage recovery of sugar direct from cane in India is slowly and steadily increasing.

Names of Provinces	1924-25 Recovery per cent.	1925-26 Recovery per cent.	1926-27 Recovery per cent.
Bihar and Orissa	7·96	7·98	8·67
United Provinces	7·23	7·88	7·93
Bombay, Madras and Burma . .	8·14	8·98	10·2
Total for India	7·81	8·07	8·41

What progress British India has to make to provide for its own requirements of sugar will be seen from the fact that she has to import over 700,000 tons of sugar from abroad.

The imports of sugar through ports in British India in 1927-28 amounted to 725,800 tons valued at Rs. 14½ crores as against 826,900 tons valued at Rs. 18⅜ crores in 1926-27. The decrease was due to the fact that at the beginning of the year stocks of sugar in India were ample to meet the demand and the fall in price as the result of increased supplies made buyers adopt a hand-to-mouth policy. The following table shows the wholesale price per maund of sugar in Calcutta.

	Rs.	A.	P.		Rs.	A.	P.
1st July, 1926 . .	12	6	0	1st July, 1927 . .	10	11	0
1st August, „ . .	10	7	0	1st August, „ . .	10	6	0
1st September, „ . .	10	15	6	1st September, „ . .	11	0	0
1st October, „ . .	11	5	0	1st October, „ . .	10	8	6
1st November, „ . .	11	2	0	1st November, „ . .	10	0	6
1st December, „ . .	12	9	0	1st December, „ . .	10	6	0
1st January, 1927 . .	13	2	0	1st January, 1928 . .	10	0	3
1st February, „ . .	12	5	0	1st February, „ . .	9	12	0
1st March, „ . .	12	1	0	1st March, „ . .	9	13	6
1st April, „ . .	11	2	6	1st April, „ . .	10	9	0
1st May, „ . .	11	1	0	1st May, „ . .	11	2	0
1st June, „ . .	11	4	6	1st June, „ . .	10	15	6
				30th „ „ . .	10	1	0

IV. Statistical.

The Bureau continued to obtain price quotations for various grades of *gur* or *jaggery* from the principal *gur* centres in India and arranged to have them published in "The Indian Trade Journal". An article on *Gur* and its prices in India was published by Rao Saheb Kasanji during the year. It was of great value in placing before the public information of a nature likely to promote inter-provincial trade. This side of the Bureau's work has been further developed by the comple-

tion of arrangements to obtain price quotations from centres in Bihar and the Punjab. It is also satisfactory to record the reduction in freight rates recently sanctioned on State Railways for *jaggery* carried to long distances by rail.

Quotations for Java white sugar at Soerabaya and of Indian factory-made sugar as also the figures of stocks of sugar at the principal ports in India were regularly supplied once a week to the Department of Commercial Intelligence and Statistics, Calcutta, for publication in " The Indian Trade Journal ". Latest information regarding sugar crops in other countries of the world was also furnished to that department for incorporation in their All-India sugarcane forecasts published in August, October and February. The Bureau continued to publish information regarding the cane and beet crops of the world as far as possible in the form of notes in " The Indian Trade Journal " and also an annual review of the general sugar position with special reference to India and the Indian crop.

The Sugar Cable Service which is designed to get early and reliable information regarding crop and market conditions in important sugar countries of the world continued to be conducted on the subscriptions received from the sugar importers and manufacturers of whom its membership consists. Recently the subscription rate for the postal branch of this service has been reduced to Rs. 15 per month so as to enable a larger number of people to avail themselves of the benefits of this service.

V. Miscellaneous.

Library. During the year under report 250 volumes were added to the Library. These were received either by purchase, exchange, or free supply, or by binding loose copies of the periodicals obtained in the library. Those interested in sugar manufacture and sugarcane cultivation consulted the library occasionally in person or took books on loan.

Museum. Samples of Indian factory made sugar were obtained in the working season 1926-27 and these replaced the old ones in the museum. A fresh set of Java sugar samples has been obtained and placed in the museum so that Indian factory made sugars can be compared with the appropriate Dutch Standard of Java sugar.

The following two articles were published during the year :—

(1) A review of the Sugar Trade in India during the year 1926-27, by Wynne Sayer. Supplement to " The Indian Trade Journal ", dated 8th December, 1927.

(2) " Gur and Its Prices in India ", by Kasanji D. Naik. Supplement to " The Indian Trade Journal ", dated 1st March, 1928.

Besides these, 31 notes giving statistical information were published in "The Indian Trade Journal" and 3 notes in "The Agricultural Journal of India".

VI. Conclusion.

As a clearing house of information the Bureau supplies such information as is available to the public and officers in the provinces and Indian States on all branches of the sugarcane industry. Capitalists desirous of erecting factories consult the Bureau about the best locality, most suitable process of sugar manufacture, machinery, arrangements regarding cane supplies, etc. When any enquiry is purely technical the party is placed in touch with the proper authority to be consulted. The attention of those interested in the development of the Indian sugar industry is drawn to the progress being made in foreign countries and the efforts that should be made to deal with such competition. There is no other agency in this country to place such up-to-date information before the public. But something more than this is required to be done if sugarcane cultivation is to continue to pay the ryots in the future. From the latest information in the possession of the Bureau, it can be confidently asserted that the already strong position of Java has been further strengthened by the remarkable achievements of the P. O. J. cane 2878 in the year 1927-28, and with the very low figure at which Java is able to make a maund of white sugar direct from cane, it is almost certain that she will endeavour to swamp the Indian market as there is no other visible outlet for her production. It appears to me that if the recommendations of the Sugar Committee could have been carried out shortly after they were made, India would have been better able to face this situation. At present we can only watch and hope that in the coming struggle the sugar industry may receive such assistance as is due to it as an industry concerned with the food of the people.

MGIPC—M—III-1-87—14-12-28—650.